Petroleum Refiner

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What's Ahead for Synthetic Rubber

How Butyl Is Produced and Used

Bright Future Seen for Elastomers

How Solvents Can Affect Dewaxing

Distillation—Which Tower Where?

Design With Maintenance in Mind

For a "Quick Look" at this issue, turn the page . . .

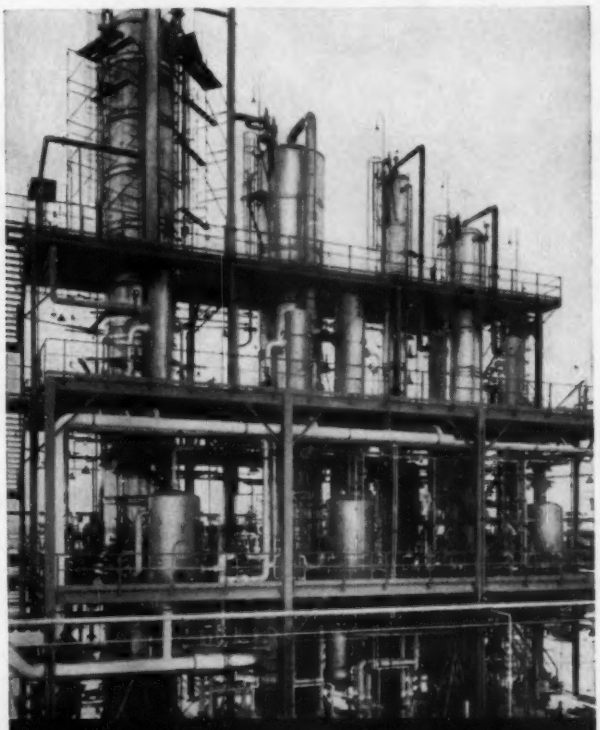
process know-how for LOWER ALIPHATIC

ALCOHOLS

CH_3OH
C_2H_5OH
iC_3H_7OH
nC_4H_9OH

FERMENTATION • SYNTHESIS
PURIFICATION
DEHYDRATION • RECOVERY

Vulcan's accumulated experience with lower aliphatic alcohols goes back over 50 years — covers hundreds of installations throughout this country and abroad — establishes Vulcan as the leading designer and constructor of plants and units for production and recovery of alcohols.



Large synthetic ethanol plant by Vulcan Engineering Division

- ★ Production of **METHANOL** by the Vulcan-Inventa Synthesis Process.
- ★ Production of **ETHANOL** by fermentation or by synthesis from ethylene.
- ★ Production of **ISOPROPANOL** by synthesis from propylene.
- ★ Production of **N-BUTANOL** by fermentation.
- ★ Dehydration by Vulcan's Pressure Process — applicable to the water-miscible alcohols which form constant-boiling mixtures with water.
- ★ Recovery and Purification of methanol, ethanol, normal propanol, isopropanol, normal butanol, secondary butanol, tertiary butanol, isobutanol and several of the amyl alcohols.

Vulcan's experience will provide the answers for many of YOUR problems in the production or recovery of the lower aliphatic alcohols. Your inquiry is invited.

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Volume 36, No. 3 March, 1957

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Petroleum Refiner

REFINING • PETROCHEMICALS • NATURAL GASOLINE

A Quick Look at This Issue

These handy digests permit checking those articles you want to read first.

SPECIAL REPORT ON SYNTHETIC RUBBER

☐ **Trends in Synthetic Rubber Growth . . .** Developments indicate the present pattern of dynamic growth will continue. Trends that will affect rubber's future are discussed in this timely industry survey. You will also find excellent material to provide economic background for your expansion plans. Turn to **Page 144.**

☐ **Compare Today's Synthetic Rubbers . . .** Here is a comprehensive review of the methods of manufacture and differences between the various types of synthetic rubber. Uses and limitations along with physical properties for all types are discussed. Clip this refresher course in rubber for your permanent files. Turn to **Page 148.**

☐ **Take a Look at Butyl Rubber . . .** Outstanding characteristics give exceptional properties to butyl, the only synthetic rubber derived entirely from refinery products. Production is quite simple and its applications are varied. In short, butyl rubber has a bright future—and here are some excellent ways to pin point its immediate uses. Turn to **Page 154.**

☐ **Future Fields for Elastomers . . .** The same rising labor costs that continually burden applications of new materials should help to increase use of elastomers. These petrochemical materials permit savings in weight, fabrication, time and less severe tolerances. For a "crystal ball" view of elastomers—the petrochemicals of the future—turn to **Page 160.**

☐ **Find Depreciation Rate by Nomograph . . .** Percentage depreciation can be determined for any year during the expected life of a piece of equipment by solving an arithmetic progression. This nomograph takes all the work out of the problem and

Please Turn Page ➔

A Quick Look at This Issue . . .

gives you an answer—quick. Put this one in your work note book. Turn to **Page 164.**

☐ **Examine Solvent Dewaxing . . .** This is the first of a two-part series describing the effectiveness of some solvent mixtures used to dewax mineral oils. A method is described for comparing your solvent with others. Take a look at the comparisons made by these authors. Turn to **Page 165.**

☐ **Which Tower Goes Where? . . .** A distillation system to separate a feed into three or more fractions may have several possible tower arrangements. Here are some excellent "rules-of-thumb" for choosing the best arrangement. Turn to **Page 169.**

☐ **V—L Equilibrium for Naphthenes and Paraffins . . .** H. S. Myers gives you experimental data on seven systems in this important family of hydrocarbons—also a summary of the behavior of aromatics. If you have treated these systems as ideal solutions, then you will need these data for your notebook. Turn to **Page 175.**

☐ **Allowable Entrainment at Minimum Cost . . .** Use minimum-cost criterion in terms of allowable entrainment in tower design in contrast to the minimum allowable velocity concept. This enables the rapid selection of the most economical tower for the specified capacity. Use this empirical relationship in your next tower design problem. Turn to **Page 179.**

☐ **Simplify Flash Distillation Calculations . . .** with this systematic method which lends itself perfectly to a program statement for a digital computer calculation. The equations converge rapidly giving an accurate solution in about three or four trials. You'll use this one, on **Page 183.**

☐ **Lubrication Scheduling Cuts Costs . . .** Here's a lube program that will trim downtime, labor and materials and increase plant profit. For complete details, turn to **Page 189.**

☐ **Save With This Automatic Lube System . . .** You can slash maintenance repair dollars when you use this system. Around-the-clock lubrication insures positive protection against faulty lubrication at all times. Turn to **Page 192.**

☐ **Design for Low Maintenance . . .** Here's a way to assure optimum maintenance results from your plant design. But you must start at the plant's roots—the initial design stage. Turn to **Page 195** for full details.

☐ **Hydrogen Use High for Some Stocks . . .** The nature of the charge stock influences amount of hydrogen required for treating. A study of the Unifining process shows some of the reactions which may occur. Learn what type of stocks require more hydrogen, turn to **Page 201.**

☐ **SIBP Data Back Up Octane Extension . . .** There is quite a controversy concerning how to record antiknock ratings over 100. These authors have obtained engine ratings on aromatic blends to construct a new scale. To see how well it agrees with the scale approved tentatively by the ASTM, turn to **Page 205.**

☐ **Study Catalyst Behavior With Isotopes . . .** Here's a new tool to help in refinery research. You need no longer wonder about cat cracker catalyst mixing and aging. Now these data can be determined rapidly and simply by using radioisotopes. Be sure to check this valuable tool. Turn to **Page 209.**

☐ **New Solutions For Electrical Problems . . .** Here's a new short cut approach method for solution of your electrical power and control problems. Turn to **Page 211.**

☐ **Easy Methods to Get Beam Deflection (Part 2) . . .** Concentrated loads for simple and cantilever beams are no problem with this method of determining deflection. This one is a "must" for your work notebook. Turn to **Page 215.**

☐ **Having Trouble With Parallel Pipe Flow? . . .** Here's a method that will really reduce the time you spend in calculating the percent of flow in parallel piping systems. For complete details, turn to **Page 219.**

☐ **Estimate Heats of Vaporization Quickly . . .** Finding vaporization heats for hydrocarbons can be a tedious problem. The empirical equation presented here permits prediction within the normal range of engineering accuracy with least effort and data. Add this time saver to your work book now. Turn to **Page 221.**

☐ **Check Engine Trouble Before It Starts . . .** Here's a set of periodic inspections that will allow you to detect trouble in your engine before it starts. Thus, it will be on-the-line longer and require the least maintenance. Turn to **Page 224.**

☐ **Heat Transfer Rates for Gases . . .** can be made easier and faster with these graphical methods. Correction factors for tube thickness and properties of the gas are considered in this graphical solution. Regardless of whether your gas is flowing on tube-side or shell-side, there's a graph here to fit your needs. Turn to **Page 226.**

☐ **Automation Today (Part 9) . . .** Subsequent parts of this series considered each of the elements of the control loop, with the exception of the process itself. Now the authors suggest some ways to handle the process as part of a control system. See how they work an example involving a heat exchanger. **Page 229.**

Petroleum Refiner

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PETROLEUM REFINER and The REFINERY CATALOG for the refining, natural gasoline, petrochemical industry.

WORLD OIL (formerly The Oil Weekly) and The COMPOSITE CATALOG for the drilling-producing industry

PIPE LINE INDUSTRY and The PIPE LINE COMPOSITE CATALOG (first edition to be issued in July, 1957) for the oil and gas pipe line industry.

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"Boxscore's" How

A REAL SERVICE to the industry, "Construction Boxscore" (featured in PETROLEUM REFINER's January, April, July and October issues) is a product of considerable editorial effort and much down-to-earth cooperation by our oil company friends. Commenced in September, 1947, when it occupied an entire page, it has developed until now each of its quarterly appearances requires some 10 pages of space.

During its almost ten years "The Boxscore," as it has come to be known, has proved its value over and over to the industry at large. It takes a lot of work to get it together and in this connection we would like to pay tribute to the hundreds of companies who over the years have responded faithfully to our letters requesting information. Because of this fine participation "Construction Boxscore" is as good as it is and fills a real industry need. It takes all hands to keep the mass of data anywhere near complete and accurate and we bespeak the continued cooperation of all involved. Be it known that at all times we welcome in behalf of our Boxscore the three C's, viz., comment, criticism and contributions!

Gasoline Plant Inning

PETROLEUM REFINER has on its books more subscribers interested in natural gasoline than any of its contemporaries. For them particularly, Editor George Gibbs is brewing a rare dish for the April issue when PR's annual Special Report on Natural Gasoline will appear. A variety of topics, each handled by an expert in the field, has been selected and the end result will be a mighty readable and valuable package.

(For you who might have another impression, capital expenditures for natural gasoline plants in 1957 will rise from $50 million, the 1956 figure, to $65 million, this even though '57 may not be one of the rich years for this segment of the industry. Maintenance and repair, of course, are in addition.)

Anxious to Hear

WANT TO KNOW how you can chip in and help make our Handbook (refining processes in even years and petrochemical processes in odd years) more useful to the industry? It's just this simple: write and give us your ideas of how the presentation could be improved. Or tell us to what use you have put the descriptive processes published in previous issues. Thereby we get the pulse and can better judge an industry's needs. PETROLEUM REFINER editors always welcome suggestions and criticism. And this applies to ALL issues, not the Handbooks exclusively.

•

A PICTURE OF OIL, in the light of today's economic factors, is contained in an eight-page brochure that you will find inserted in this issue of PETROLEUM REFINER. The facts and figures presented deserve closest study. And they are the sort that you will want your friends to see.

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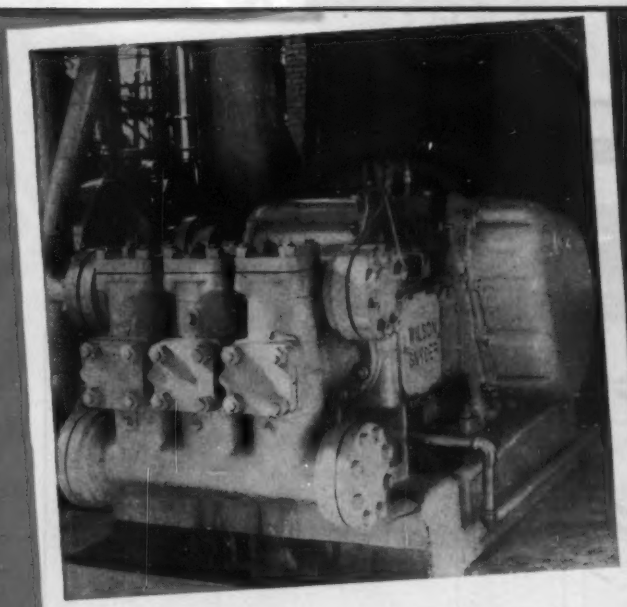

Typical Wilson-Snyder triplex plunger power pump in Universal Oil Products Platforming reactor charge service.

Typical Wilson-Snyder duplex steam pump handling naptha charge in an Atlantic Catforming installation.

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—your best buy for LOW-Capacity, HIGH-Pressure Services

RECIPROCATING pumps offer many money-saving advantages over multistage centrifugals from 20 to 200 gpm when the differential head in feet is over 20 times the gpm.

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EXPERIENCE—For over 75 years, Wilson-Snyder has furnished heavy-duty pumps of the highest quality, and performance records in thousands of refinery installations throughout the United States and foreign countries have established them as the industry's finest pumps. As a builder of both centrifugal and reciprocating types (including power and direct-acting steam) you can be sure of an unbiased recommendation as to which type will best suit your conditions.

Give your nearest "Oilwell" Pump Specialist an opportunity to quote on Wilson-Snyder pumps for your requirements.

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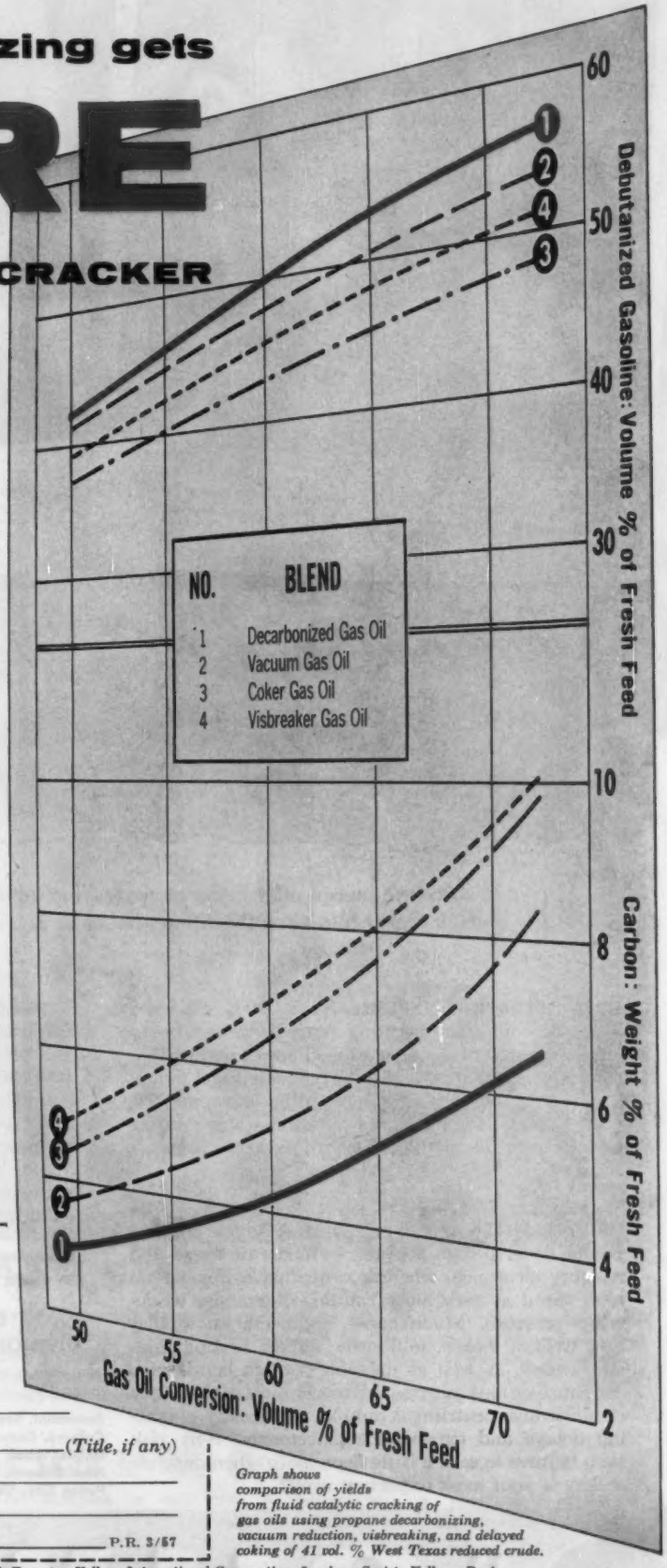

Graph shows comparison of yields from fluid catalytic cracking of gas oils using propane decarbonizing, vacuum reduction, visbreaking, and delayed coking of 41 vol. % West Texas reduced crude.

Refinery Process Division
THE M. W. KELLOGG COMPANY
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Send copy of your 16-page Kelloggram, describing Solvent Decarbonizing and its economic advantages.

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For more data on advertised products, use Readers' Service Cards, last page.

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ALUNDUM fused alpha alumina, one of many electrochemically refined materials produced by Norton Company, is gaining increased preference for many industrial uses.

It is available in a number of forms. Of these, 38 ALUNDUM grain has proved particularly successful in applications demanding high purity. Electrically fused from Bayer-processed alumina, this white grain is 99.49% pure Al_2O_3. It is insoluble in common solvents, extremely resistant to reduction and is an amphoteric refractory with high dielectric strength. Other characteristics include:

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Hardness	9.0 Mohs' scale
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Norton Also Electrochemically Refines

CRYSTOLON* silicon carbide, MAGNORITE* magnesium oxide, NORBIDE* boron carbide, FUSED ZIRCONIA and many others, including a number still under development. Having varied applications in many fields, these high-melting materials are also basic ingredients of the famous Norton Refractory Rx's — refractories *engineered and prescribed* for the widest range of uses.

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In Thermal Cracking Reactors

Particularly in Wulff Process Generators for cracking light hydrocarbons to produce acetylene gas and Koppers-Hasche Generators for cracking light hydrocarbons to produce a variety of gases and petrochemicals — checkers made of Norton ALUNDUM high-purity fused alumina provide definite advantages. Their excellent heat transfer properties, high refractoriness and resistance to erosion caused by hot gases are important. Their ability to withstand the thermal stresses of intermittent operation assures long life. And their purity prevents side reactions with the reacting gases, thus safeguarding product quality.

In Pebble Heaters

ALUNDUM heat exchange pebbles are giving excellent results in pebble heaters for heating gases above operating temperatures permissible in conventional tube furnaces. Their great resistance to abrasion, impact and repeated heating and cooling make them the ideal heat transfer medium in these devices. Also, their high refractoriness prevents them from the softening and "bridging" together that causes stoppages in the heater's moving bed.

In Gas Synthesis Generators

ALUNDUM fired shapes, backed up with ALUNDUM insulating castable, provide ideal linings for generators of this type because of their high-purity, high refractoriness, chemical stability, and inertness to reaction with contacting atmospheres.

Many Other Uses

for Norton high-purity fused alumina materials include: pure oxides and sintered refractories, refractory cements, wear-resistant parts, laboratory ware, etc.

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For more data on advertised products, use Readers' Service Cards, last page.

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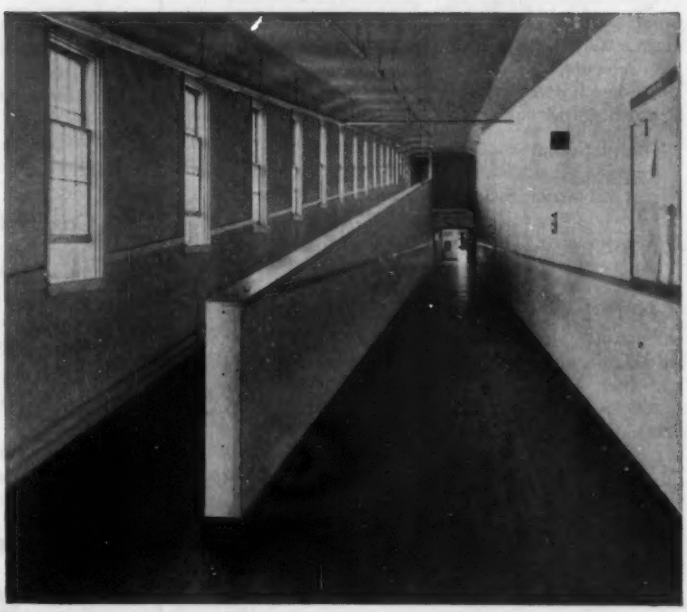
K&M Apac is the ideal low-cost, long-life building material. It is made of two practically indestructible ingredients . . . asbestos fiber and portland cement . . . and actually grows harder and more durable with age. K&M Apac cannot burn, rot or corrode, nor can it be damaged by vermin or rodents. Apac is easily sanitized with soap and water.

PRACTICALLY NO MAINTENANCE NEEDED, indoors or out! K&M Apac sheets are highly weather-resistant. Their natural gray color is attractive and no painting is required for protection.

INEXPENSIVE APPLICATION is possible with K&M Apac . . . large 4′ x 8′ sheets can be applied on a big area quickly, and even unskilled labor can cut, drill or shape them on the job without special equipment.



K&M Apac is ideal for this ramp-wall which must be rugged to withstand the continuous scuffing and scraping of heavy traffic.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos

ALLIS-CHALMERS

ON THE JOB

Happy Solutions To 4 Typical Water Problems

● Everybody seems to have problems when they use water. It's too pure, or it isn't pure enough . . . or it needs conditioning for the job it has to do. In any case, a specialist is needed. Here are typical examples of Allis-Chalmers water conditioning service, equipment and chemicals at work solving varied water problems.

Drought Adds to Woes of River Water Users

CALIFORNIA—Things looked bad at a paper company when the first water samples came in. In fact, one water conditioning company went so far as to say that the alkalinity of the water could never be reduced to a satisfactory level.

But on the assurance of Allis-Chalmers experts, a de-alkalizer was ordered for boiler make-up water.

In the meantime there was a drought. The drought made the river water conditions even worse than they had been, so that by the time the equipment was installed there was real trouble with alkali.

Allis-Chalmers engineers had an unusually tough problem on their hands. Instruction, experiment, on-the-spot service, and a program of constant control have resulted in production of satisfactory boiler make-up.

Saved $60,000 in New Equipment

LOUISIANA—A low pressure industrial steam plant was being supplemented by a 1250-lb boiler. The question arose—can any of the old water conditioning system be used? Preliminary investigation indicated the need for demineralization equipment to get the desired water quality for make-up in the new equipment.

A survey of the records showed that it would be possible to use condensate from the low pressure system as make-up for the high pressure system. This solution of the problem required less modification of equipment than was originally anticipated . . . saved an estimated $60,000.

Stained Glass Has Its Place, But Not in Nursery

ILLINOIS—A nursery was spraying water over the outside of its glass hothouses to control the temperature inside. The method was effective, but the iron stains from the water were troublesome. Allis-Chalmers water conditioning experts recommended A-C's 130 Series complexing agents. This did the job by preventing the iron from depositing on the glass.

Battle with Algae Ends in Knockout

KENTUCKY—A petroleum company is finding out what a lethal weapon Allis-Chalmers new 120 Series algaecide really is. Previously they used sodium hypochlorite, but their cooling tower algae problems were not solved. Now they have complete control . . . using concentrations of only one-half of what is normally recommended. They also say it's easier to handle and apply, and better in every way, than anything they've ever used before.

Get Help on Your Water Problems

Whether you need chemicals, equipment or service, Allis-Chalmers provides an unbiased recommendation based on over 25 years' experience. No problem is too big or too small. Specialists are located in many cities. Call your nearby A-C office or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5304

all of these steam traps are impulse!

Take your choice! There is a Yarway Impulse Steam Trap for practically every trapping requirement in your plant.

Revolutionary when introduced 20 years ago, the *Yarway Impulse* principle has been proved by more than a million in service everywhere, is still gaining new friends every day.

SERIES 60—for *normal steam trap requirements;* pressures to 400 psi, temperatures to 450° F. Stainless steel body and working parts. Six sizes, ½" to 2".

NO. 20-A—available in ½" size only— similar to ½" #60, but with low capacity—designed especially for *light condensate loads.*

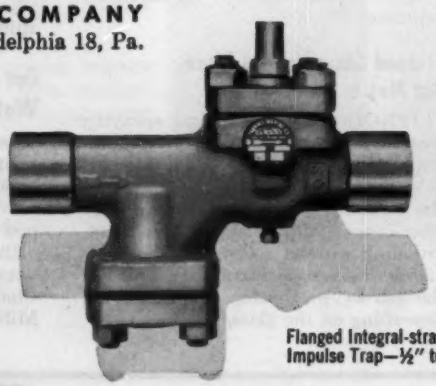
SERIES 120—same as Series 60 but for higher pressures and temperatures (600 psi, 750° F). Featuring all-stainless steel construction. Six sizes, ½" to 2".

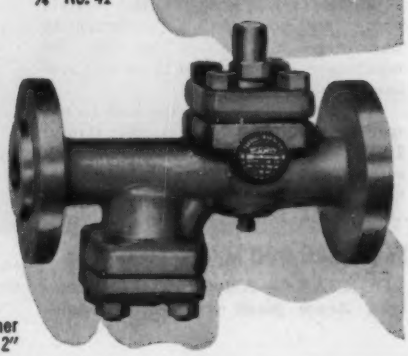
SERIES 40—for *heavy condensate loads* requiring high capacity traps. Sizes ½" to ¾" in stock, larger sizes (1½", 2", 2½") available.

INTEGRAL STRAINER TRAPS—for marine use and for high pressure trapping service in steam power plants with pressures up to 2500 psi. Six sizes, ½" to 2"; flanged and socket-welding ends.

All Yarway Impulse Steam Traps are available through 270 convenient local Industrial Distributors. For descriptive bulletin on any type of Impulse Trap, write . . .

YARNALL-WARING COMPANY
128 Mermaid Avenue, Philadelphia 18, Pa.


Socket-weld Integral-strainer Impulse Trap—½" to 2"


Flanged Integral-strainer Impulse Trap—½" to 2"

YARWAY IMPULSE STEAM TRAPS
The Impulse that revolutionized steam trapping 20 years ago

For the petroleum industry...

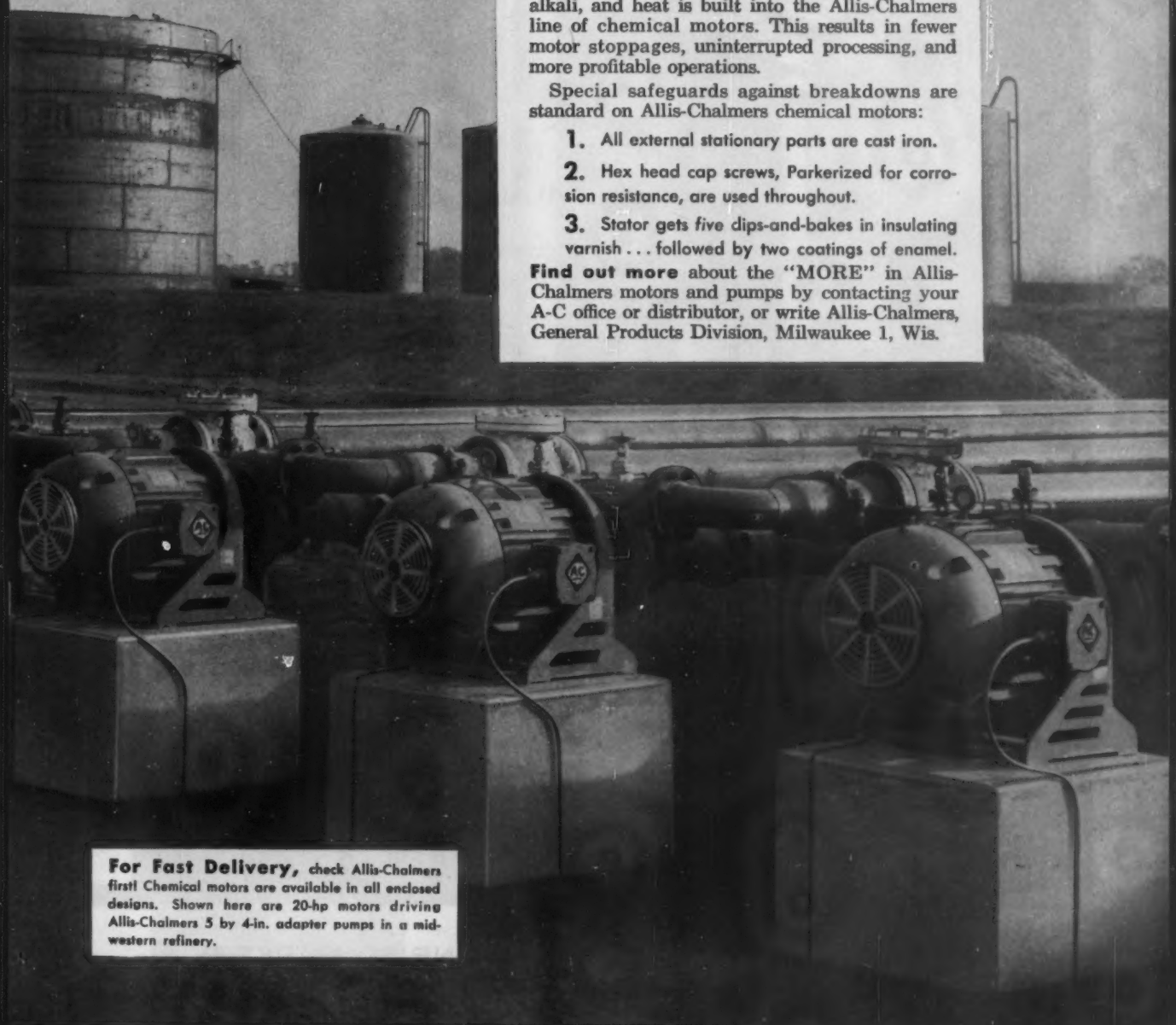
There's MORE continuous processing with Allis-Chalmers chemical MOTORS and PUMPS

Maximum protection against moisture, acid, alkali, and heat is built into the Allis-Chalmers line of chemical motors. This results in fewer motor stoppages, uninterrupted processing, and more profitable operations.

Special safeguards against breakdowns are standard on Allis-Chalmers chemical motors:

1. All external stationary parts are cast iron.
2. Hex head cap screws, Parkerized for corrosion resistance, are used throughout.
3. Stator gets *five* dips-and-bakes in insulating varnish . . . followed by two coatings of enamel.

Find out more about the "MORE" in Allis-Chalmers motors and pumps by contacting your A-C office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.

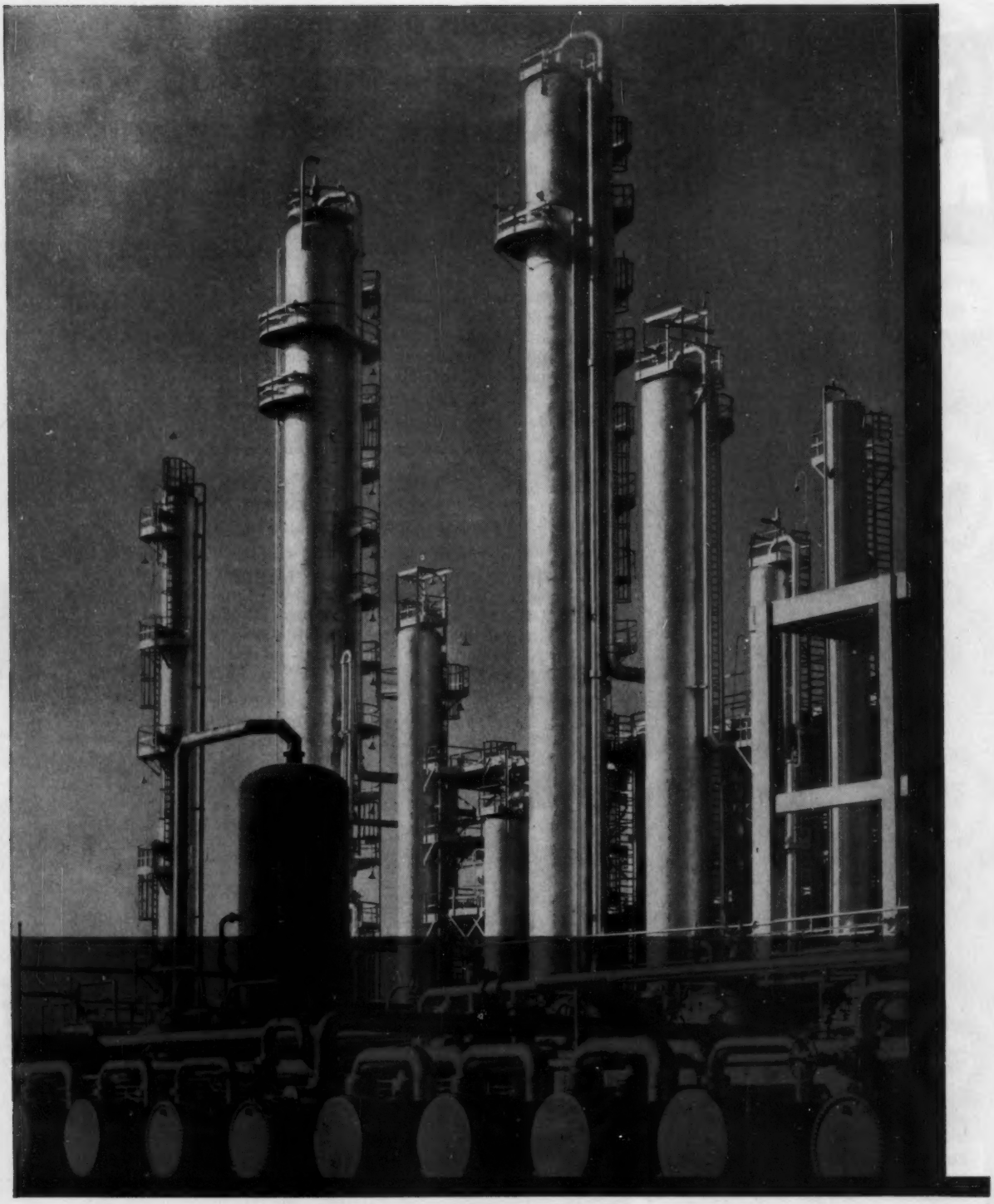


For Fast Delivery, check Allis-Chalmers first! Chemical motors are available in all enclosed designs. Shown here are 20-hp motors driving Allis-Chalmers 5 by 4-in. adapter pumps in a mid-western refinery.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5168



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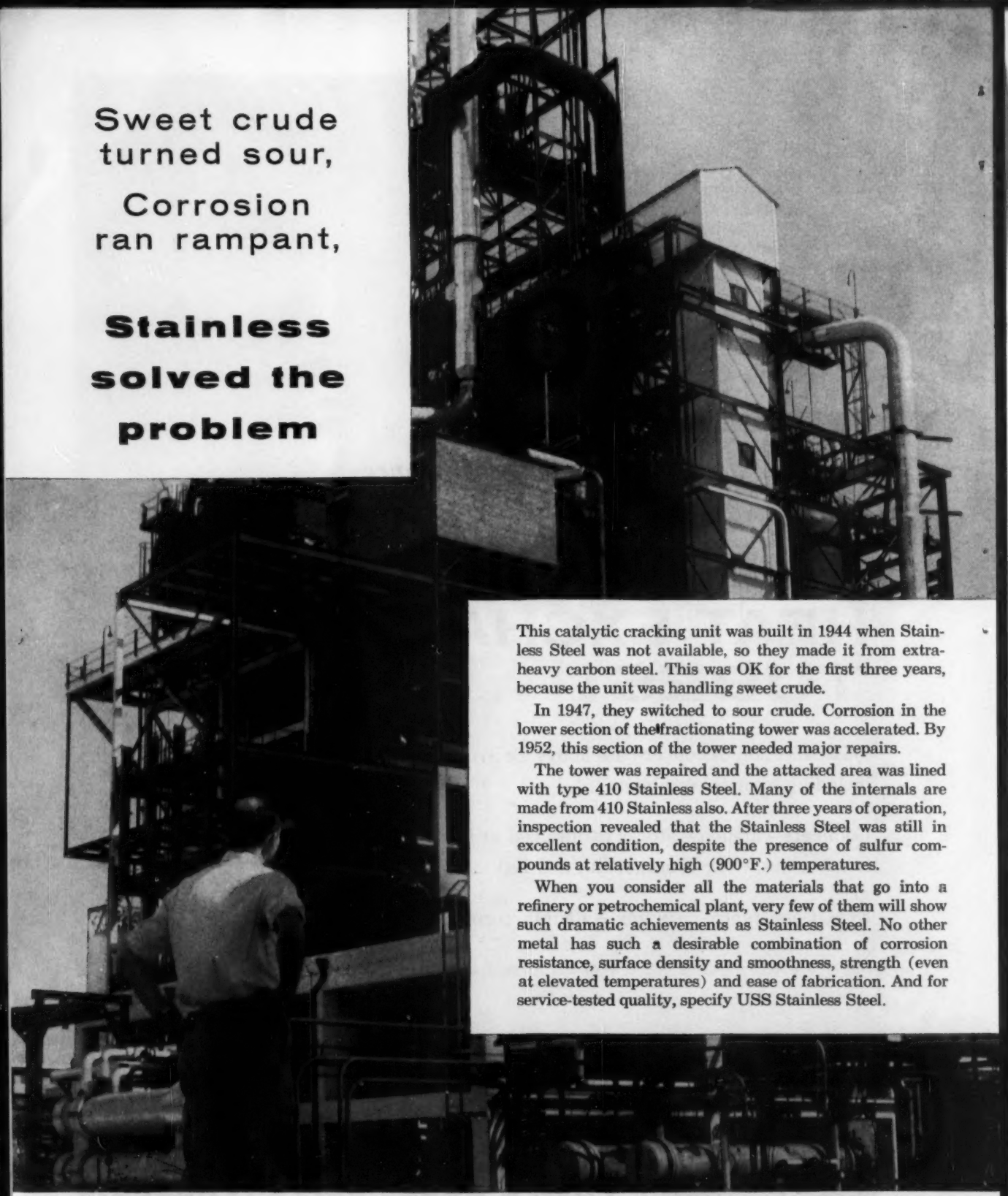
Sweet crude turned sour,

Corrosion ran rampant,

Stainless solved the problem



This catalytic cracking unit was built in 1944 when Stainless Steel was not available, so they made it from extra-heavy carbon steel. This was OK for the first three years, because the unit was handling sweet crude.

In 1947, they switched to sour crude. Corrosion in the lower section of the fractionating tower was accelerated. By 1952, this section of the tower needed major repairs.

The tower was repaired and the attacked area was lined with type 410 Stainless Steel. Many of the internals are made from 410 Stainless also. After three years of operation, inspection revealed that the Stainless Steel was still in excellent condition, despite the presence of sulfur compounds at relatively high (900°F.) temperatures.

When you consider all the materials that go into a refinery or petrochemical plant, very few of them will show such dramatic achievements as Stainless Steel. No other metal has such a desirable combination of corrosion resistance, surface density and smoothness, strength (even at elevated temperatures) and ease of fabrication. And for service-tested quality, specify USS Stainless Steel.

Cities Service Refining Corporation, Lake Charles Refinery

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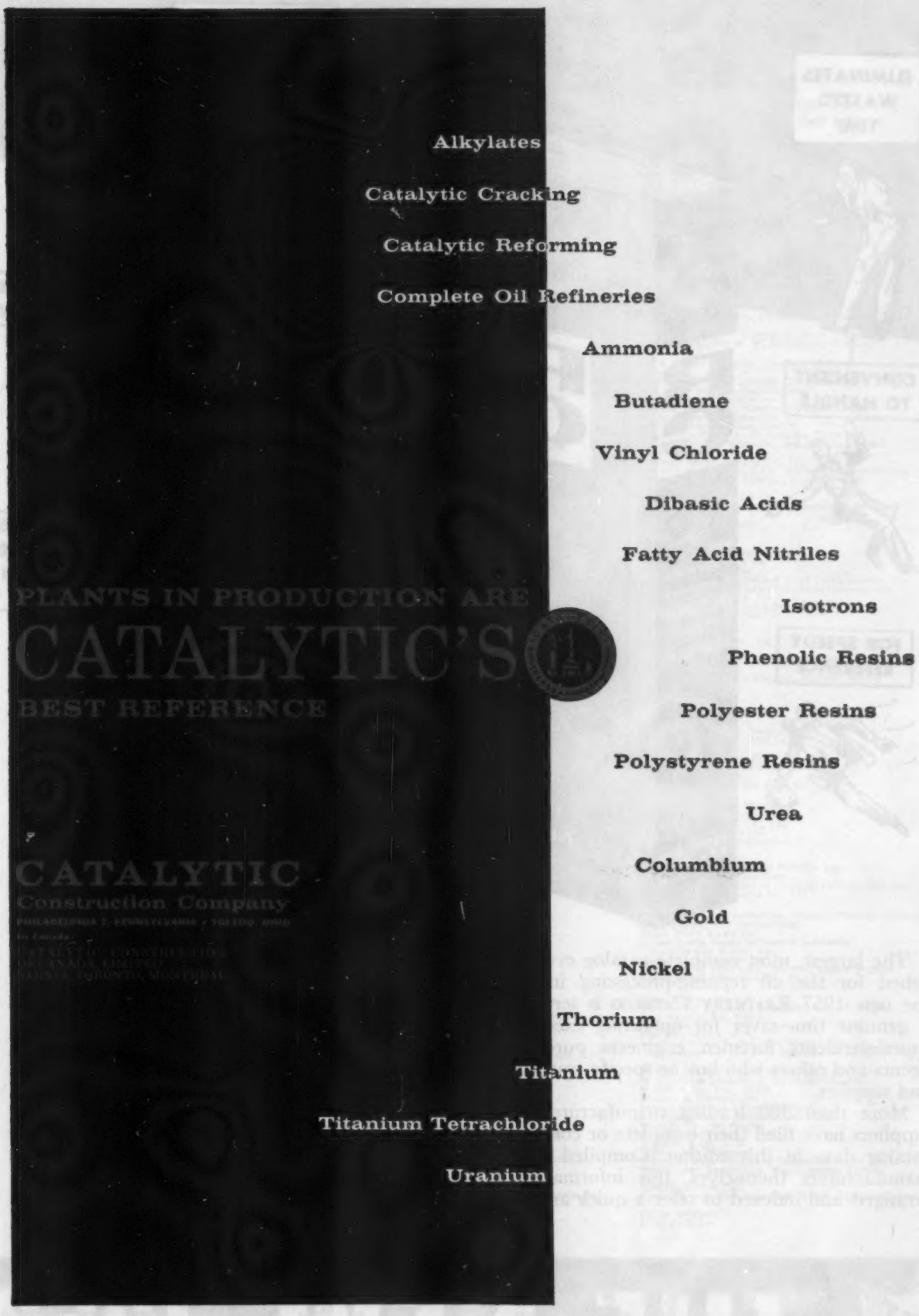
UNITED STATES STEEL



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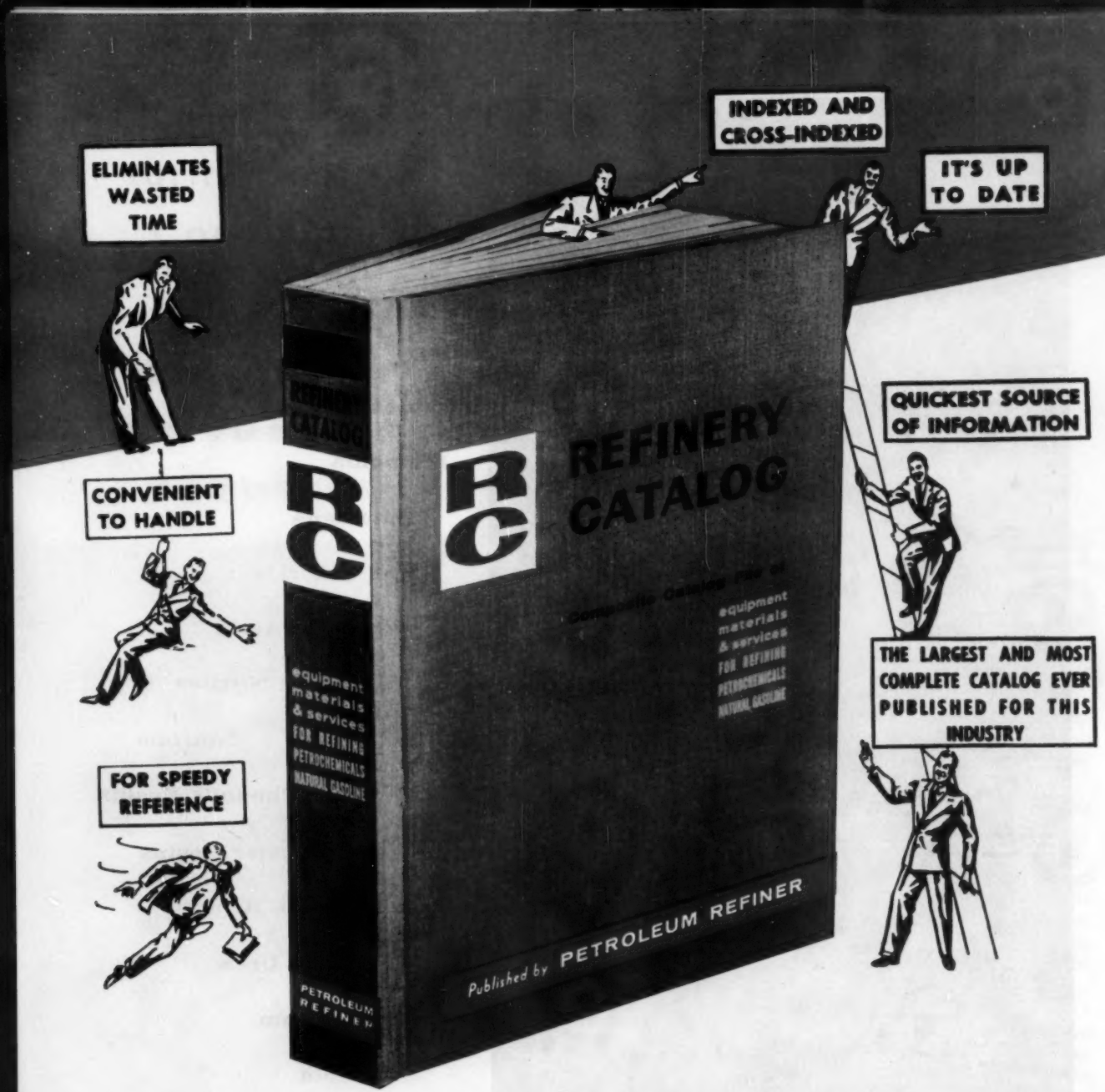
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Published by PETROLEUM REFINER

The largest, most complete catalog ever published for the oil refining-processing industry, the new 1957 REFINERY CATALOG is serving as a genuine time-saver for operating executives, superintendents, foremen, engineers, purchasing agents and others who buy or specify equipment and supplies.

More than 300 leading manufacturers and suppliers have filed their complete or condensed catalog data in this edition. Compiled by the manufacturers themselves, this information is arranged and indexed to offer a quick and convenient means of locating items of equipment and services, and sources of supply of products in which you may be interested.

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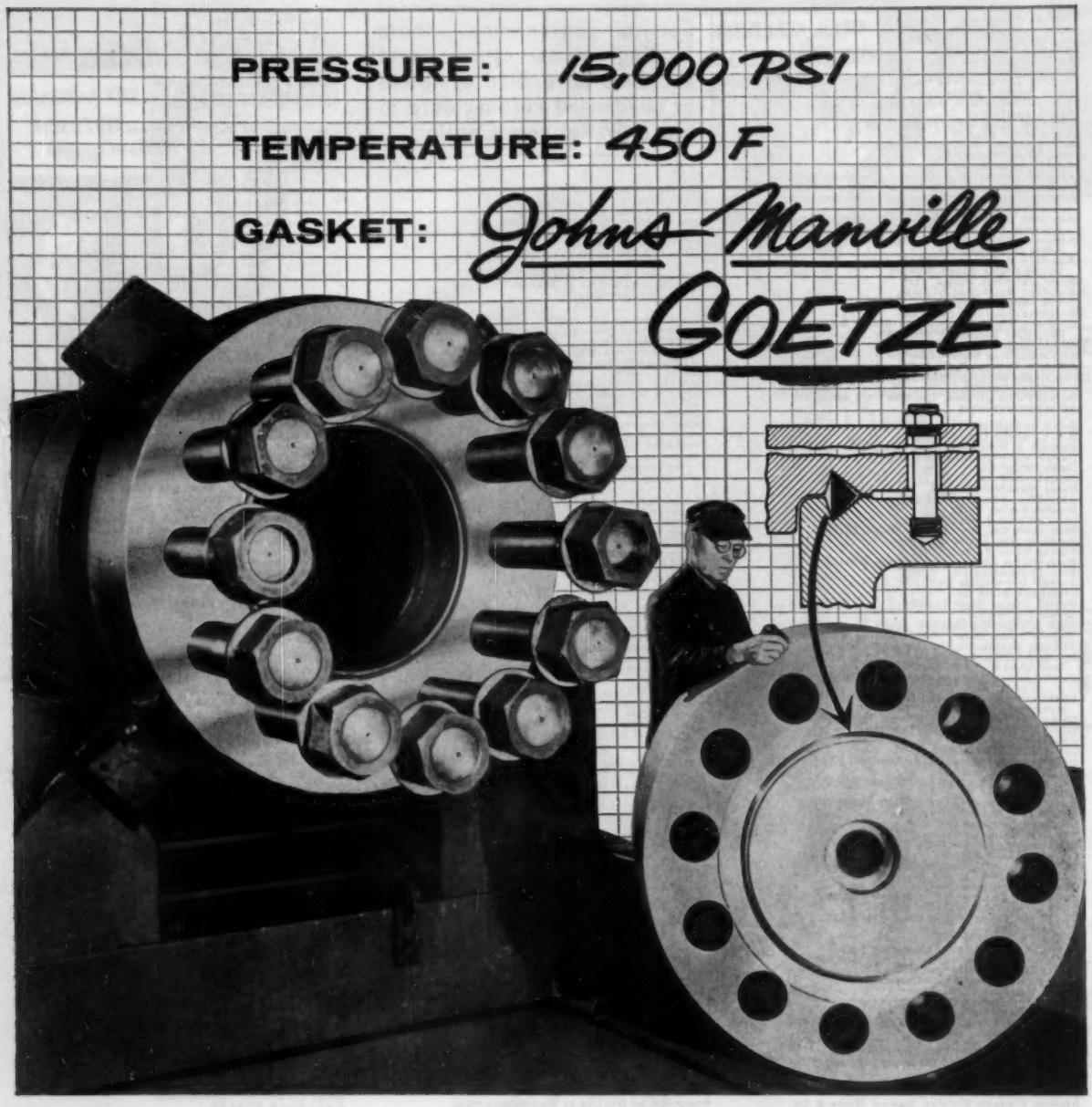

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Today's tremendous pressures and temperatures have placed special demands on manufacturers of processing equipment. A. O. Smith has answered this need with a special type of "Multi-Layer" vessel construction. And Johns-Manville in turn has provided gaskets that assure tight seals under these exacting conditions. Typical of these is the delta type gasket, illustrated above, which was designed, for this application, to withstand pressures up to 15,000 psi. and temperatures to 500 F.

The development of special gaskets to meet special purposes has been the stock in trade of Johns-Manville's Goetze division for more than sixty-five years. Expert technicians possess a knowledge of metals and other factors related to gasket design and performance that is unmatched in the field. What's more, intensive specialization and modern production tooling provide substantial cost savings on J-M gaskets.

If you need gaskets for high pressure vessels for similar applications, send us a drawing or template for quotation. If you have a sealing problem of any kind, J-M technicians will work directly with your own engineers to develop new gaskets —or adapt existing styles—to meet your specific requirements. Write for further information to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit (Toronto), Ontario.

Johns-Manville PACKINGS & GASKETS

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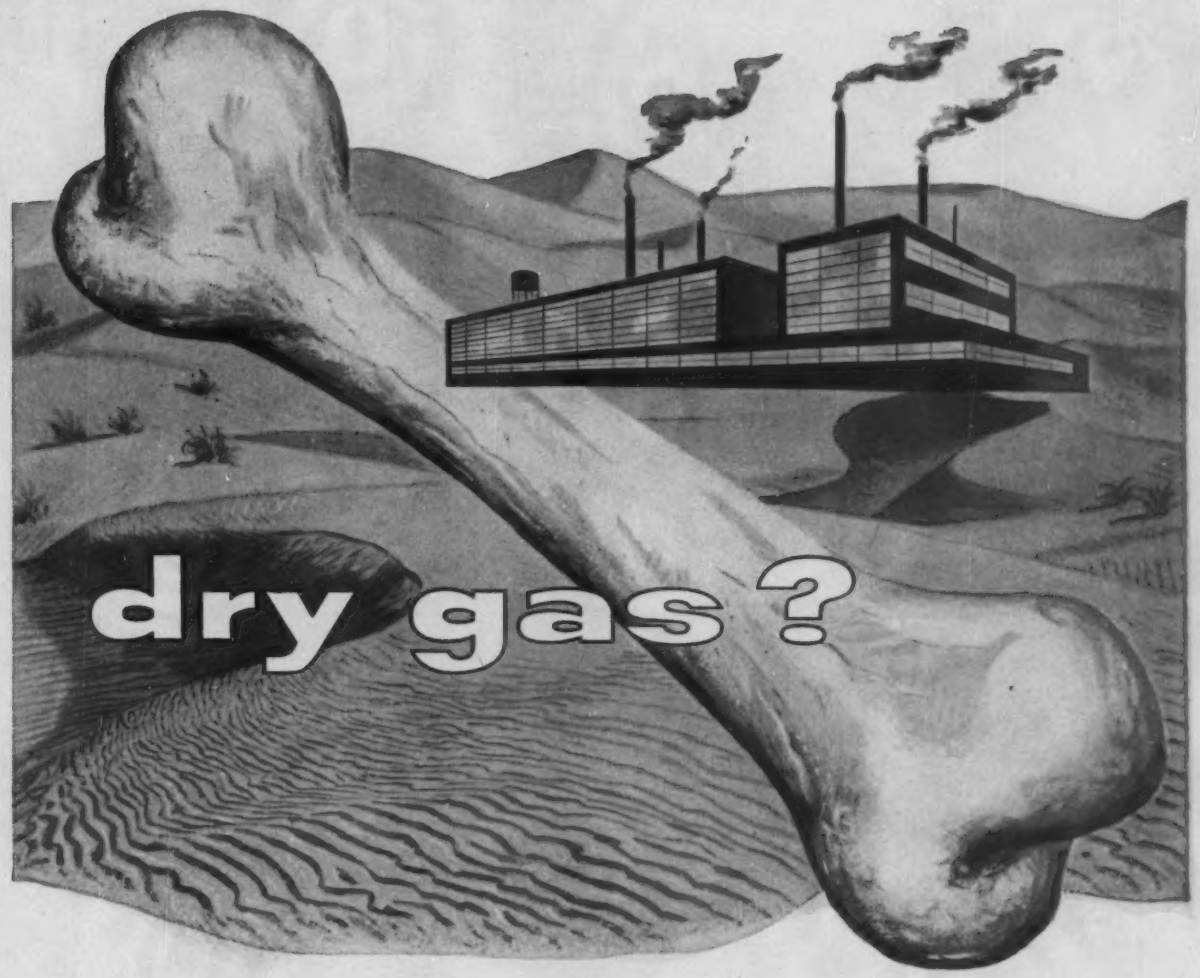
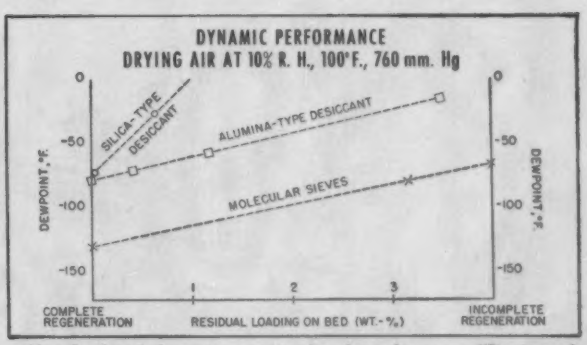


Now you can dry gases drier than dry!

LINDE Molecular Sieves can dry your gases—air, hydrogen, chemical streams—more thoroughly than any other commercial adsorbent. They will duplicate laboratory performances—*in your plant*—under normal *production* conditions.

● Even though your gas stream may already be partly dried, Molecular Sieves will remove the last traces of moisture. Only a small volume of adsorbent is required. The same combination of high capacity and low dewpoint is also obtained at high temperatures, up to 200°F.

This is SUPER-drying! Dynamic performance is shown in the accompanying graph. This superior performance also can be expected at higher relative humidities and at other temperatures and pressures. Of particular significance in production is the relative insensitivity of Molecular Sieves to incomplete regeneration.



For further information, write for data sheets on "Drying of Gases." Address Dept. **PR-3**, Linde Air Products Company, A Division of Union Carbide and Carbon Corporation, 2900 Cahaba Road, Birmingham 9, Alabama.

Linde TRADE MARK MOLECULAR SIEVES

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New engineering services on the international scene

BADGER facilities for serving the petroleum and chemical industries continue expanding!

BADGER-COMPRIMO N.V., a new company owned jointly by Badger Manufacturing Company and Comprimo N.V., has been established in The Hague. With a well-integrated staff drawn from the widely experienced Comprimo N.V. and Badger organizations, the firm is now prepared to provide full engineering, procurement and construction services in Europe and abroad.

With three domestic offices — including one in Houston just opened — and its autonomous new European affiliate, Badger services are more than ever on the international scene.

There are reasons for Badger's healthy growth — reasons that are of significant advantage to projects *you* are planning.

Write or wire today for the full story.

COMPRIMO N V

TEXAS — IN EUROPE: BADGER-COMPRIMO N. V. THE HAGUE

Honor first commercial use of Lukens Nickel-Clad Steel plate

Withstands corrosive chemical for twenty-five years . . . Nickel surfaces keep this car from deteriorating . . . Nickel-cladding for the walls . . . pure Nickel for the steam coils that keep the phenol liquid.

Catalin Corporation car completes its first 25 years keeping phenol pure

These executives are honoring an important commercial event . . . the 25-year-old development of Nickel-Clad Steel plate.

They're watching while a plaque to mark the event is welded to a tank car of the Catalin Corporation of America.

Car keeps 8000-gallon shipments of molten phenol in original purity

It was built by General American Transportation Company with the first Nickel-clad plate ever rolled.

At the time, the application of this new, untried material took pioneering vision. But you can see the move was well justified. What's more, there's years of service left in the car.

Since this car was built, the use of Nickel and Nickel-Clad Steel to withstand corrosion by phenol and many other corrosive chemicals has been justified over and over again.

It has been proved in tanks, cars and trucks. In storage tanks. In evaporators, stills, condensers, driers. In piping.

You can count on it

Nickel and Nickel-Clad Steel prevent corrosion troubles . . . keep many sensitive chemicals free of harmful metallic impurities.

And you can count on Inco's Development and Research Division for help in applying these materials to specific items of equipment. Just write.

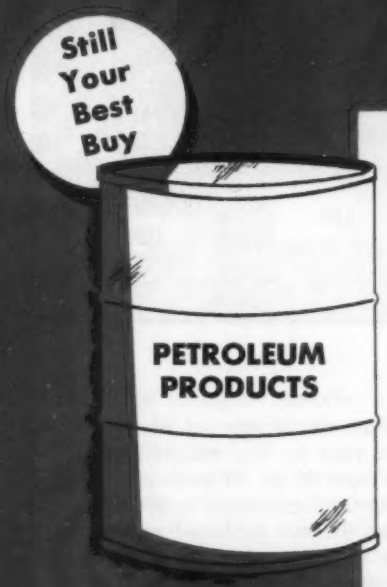
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL... *for purity*

A supplement to PETROLEUM REFINER, March, 1957

The Facts About Oil Prices

...America's Biggest Bargain



Unfair, garbled and misleading statements followed the higher crude oil and gasoline prices posted early this year. The American public is entitled to the true facts about oil prices. After all, Mr. and Mrs. America are buyers of oil products.

While other industries have raised prices every year or oftener, there have been only two oil price advances in nine years. Oil price increases have been small compared with other commodity prices.

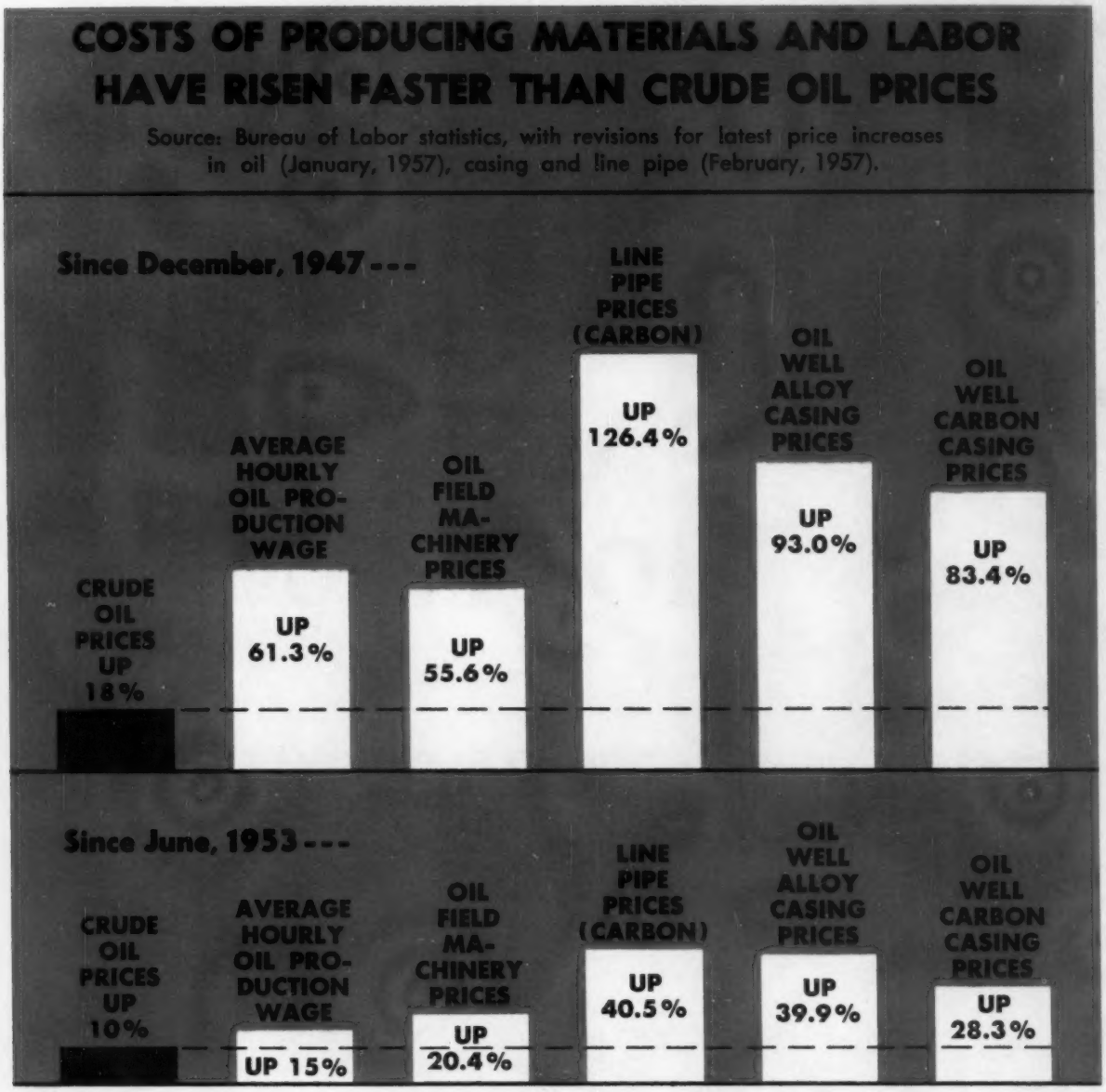
Mr. and Mrs. America still pay less for gasoline than for milk, soft drinks and many other items, although taxes constitute one-third of the price they pay for gasoline.

Oil is not the fabulously rich industry many believe. Oil earns a lower rate of return on capital invested than many other industries, and oil's return has declined while other returns have risen.

Like other businesses, oil costs have risen sharply. It is an expensive business, requiring tremendous investment. Profit rates must be adequate to attract huge investment capital. Otherwise Mr. and Mrs. America's best buy will cease to exist.

Here are the facts about oil prices . . .

Prepared for Gulf Publishing Company
Publishers of WORLD OIL, PIPE LINE INDUSTRY and PETROLEUM REFINER
By Warren L. Baker and Cecil W. Smith


COSTS OF PRODUCING MATERIALS AND LABOR HAVE RISEN FASTER THAN CRUDE OIL PRICES
Source: Bureau of Labor statistics, with revisions for latest price increases in oil (January, 1957), casing and line pipe (February, 1957).
Since December, 1947 ---
CRUDE OIL PRICES UP 18%
AVERAGE HOURLY OIL PRODUCTION WAGE
UP 61.3%
OIL FIELD MACHINERY PRICES
UP 55.6%
LINE PIPE PRICES (CARBON)
UP 126.4%
OIL WELL ALLOY CASING PRICES
UP 93.0%
OIL WELL CARBON CASING PRICES
UP 83.4%
Since June, 1953 ---
CRUDE OIL PRICES UP 10%
AVERAGE HOURLY OIL PRODUCTION WAGE
UP 15%
OIL FIELD MACHINERY PRICES
UP 20.4%
LINE PIPE PRICES (CARBON)
UP 40.5%
OIL WELL ALLOY CASING PRICES
UP 39.9%
OIL WELL CARBON CASING PRICES
UP 28.3%

Crude oil prices have not kept pace with the price gains of major elements in production costs. They remain low in comparison with the costs of labor and materials used by the industry.

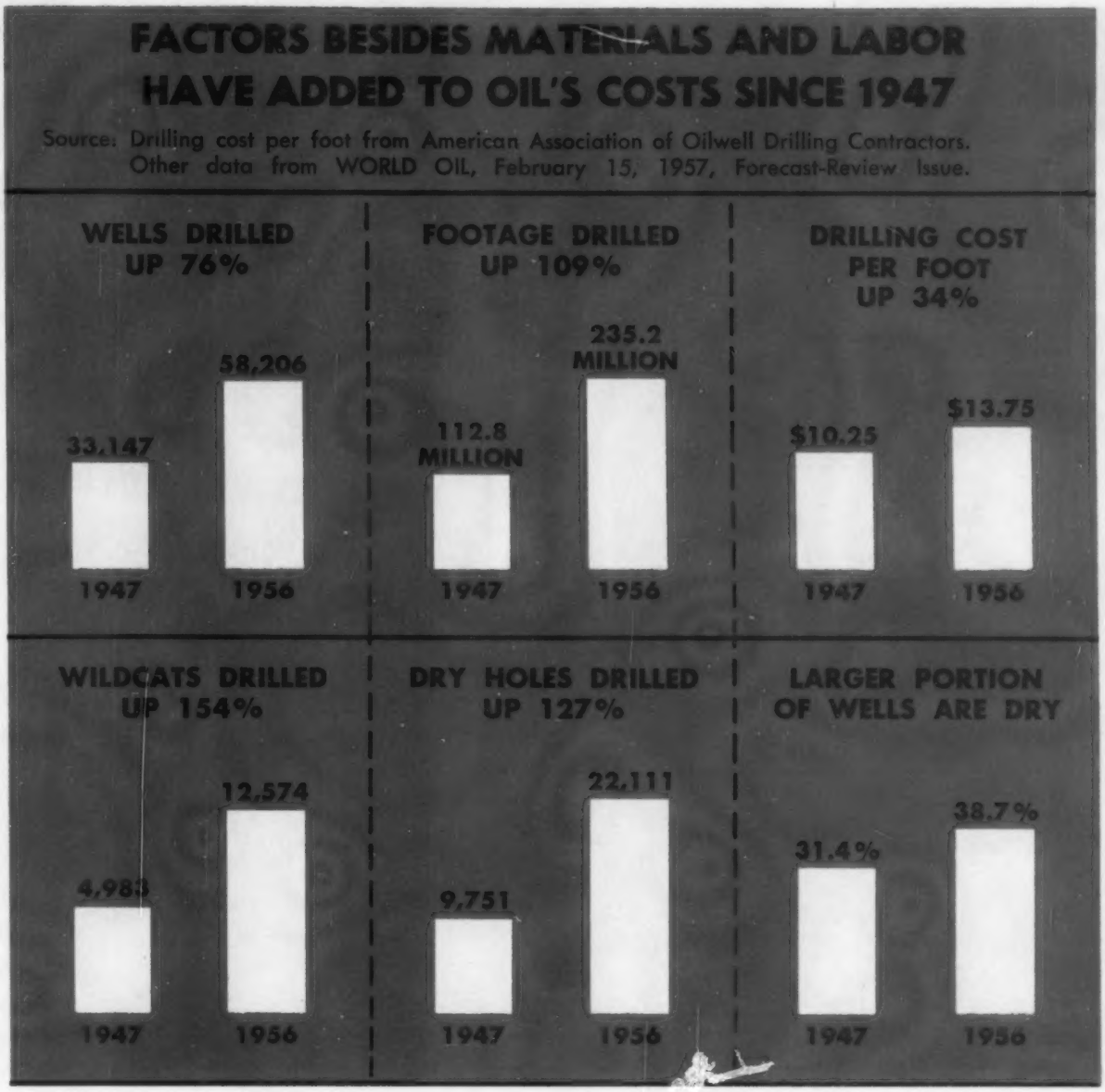
Since 1947, there have been only two general increases in U. S. crude oil prices. A 25-cent per barrel increase took place in June, 1953, and the other, which also averaged about 25 cents a barrel, in January, 1957.

Neither of these was adequate to cover increases in the cost of finding, developing and producing crude oil. Crude oil prices today are only 18 percent above 1947, whereas prices of major elements in production costs have risen three to six times faster. The 10 percent increase in crude prices during January, 1957, did not cover all the increases in prices that have taken place since 1953.

For example, the 18 percent increase in crude oil prices since 1947 compare with an increase of 61 percent in average hourly wages paid by the industry, while oil well casing has risen from 83 to 93 percent, line pipe by 126 percent, and oil field machinery by 55 percent.

Wages and steel are the two principal cost items to the oil industry. The industry uses large quantities of steel, metal and machinery, particularly in the production end of the business. It requires an average of 80 tons of steel for each new well drilled. In contrast, the average automobile requires less than two tons of steel. Yet motor vehicle prices are up 46 percent since 1947 in contrast with a gain of 18 percent for crude oil.

If this vital industry is to keep America supplied with increasing quantities of oil, it must be permitted to remain in a strong, healthy position—the price received for its product must reflect increased production costs.



In addition to higher materials and labor costs, other factors also have added greatly to the cost of finding and producing oil in the U. S.

The search for oil is big business, calling for the drilling of many wells annually to locate and develop sufficient new producing fields to satisfy the rapidly expanding use of petroleum.

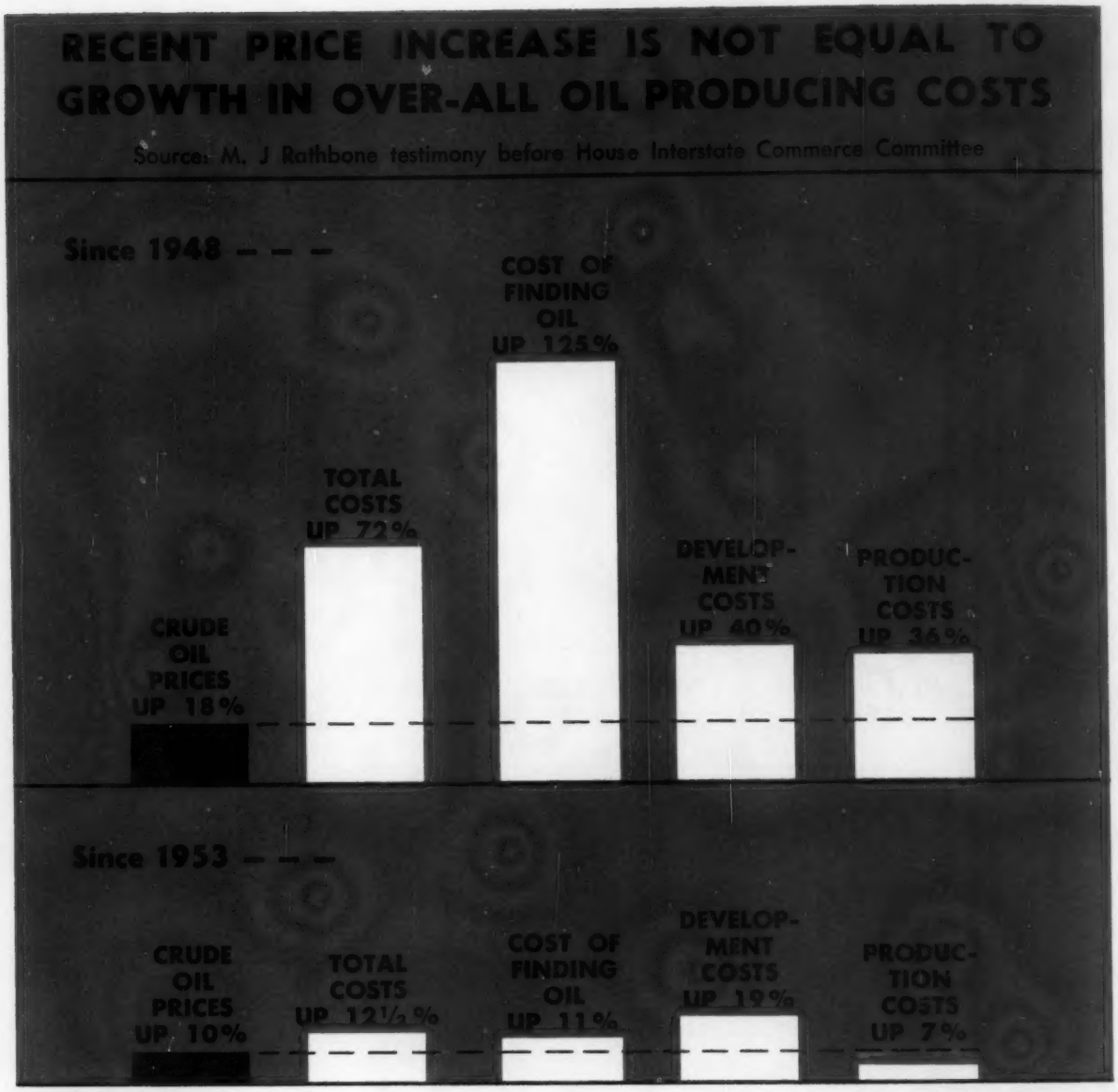
To provide enough oil to satisfy Mr. and Mrs. America's 62 percent increase in demand for petroleum products since 1947, the industry has had to greatly accelerate its expenditures for drilling operations. Between 1947 and 1956 the number of wells drilled annually increased by 76 percent. Due to greater depths of wells, footage advanced even more rapidly, rising 109 percent. Footage is a truer index of expenses, costs rising sharply with depth.

To find enough oil to satisfy rising demand, the industry has nearly tripled the number of "wildcat" tests. These are wells drilled in unproven areas seeking to discover new producing fields. Wildcats constituted 22 percent of all wells drilled in 1956, in contrast with only 16 percent in 1947.

Terrific financial odds are involved in the drilling of wildcats. Here is where many an oil man loses his pants as well as his shirt. Eighty-eight percent of all wildcats drilled invariably fail to find production—only 1 out of 9 ever produce any oil or gas. They are complete financial failures.

Increased wildcatting resulted in the drilling of 2¼ times more dry holes during 1956 than in 1947. This resulted in 38.7 percent of all wells drilled (wildcat and field development wells) being dry holes during 1956, whereas less than 30 percent were dry prior to 1946.

All these factors have tended to add greatly to the cost of finding and producing oil in the U. S.


RECENT PRICE INCREASE IS NOT EQUAL TO GROWTH IN OVER-ALL OIL PRODUCING COSTS
Source: M. J Rathbone testimony before House Interstate Commerce Committee
Since 1948
CRUDE OIL PRICES UP 18%
TOTAL COSTS UP 72%
COST OF FINDING OIL UP 125%
DEVELOP-MENT COSTS UP 40%
PRODUC-TION COSTS UP 36%
Since 1953
CRUDE OIL PRICES UP 10%
TOTAL COSTS UP 12½%
COST OF FINDING OIL UP 11%
DEVELOP-MENT COSTS UP 19%
PRODUC-TION COSTS UP 7%

Oil production costs have risen more than crude oil prices since World War II. Even after the January, 1957, increase crude oil prices did not equal the growth that has occurred in costs. Higher costs indicate oil price increases were long overdue.

Because of the many factors discussed on the preceding two pages, total production costs advanced 72 percent between 1948 and 1956, and by 12½ percent between 1953 and 1956. Even with the January, 1957, increase, crude oil prices were only 18 percent above 1948, and but 10 percent higher than in 1953. These are 1957 oil prices compared with 1956 oil costs.

Further increases in production costs will occur in 1957. Early February price advances for oil well casing and line pipe may add as much as $40 million to the industry's operating costs in 1957.

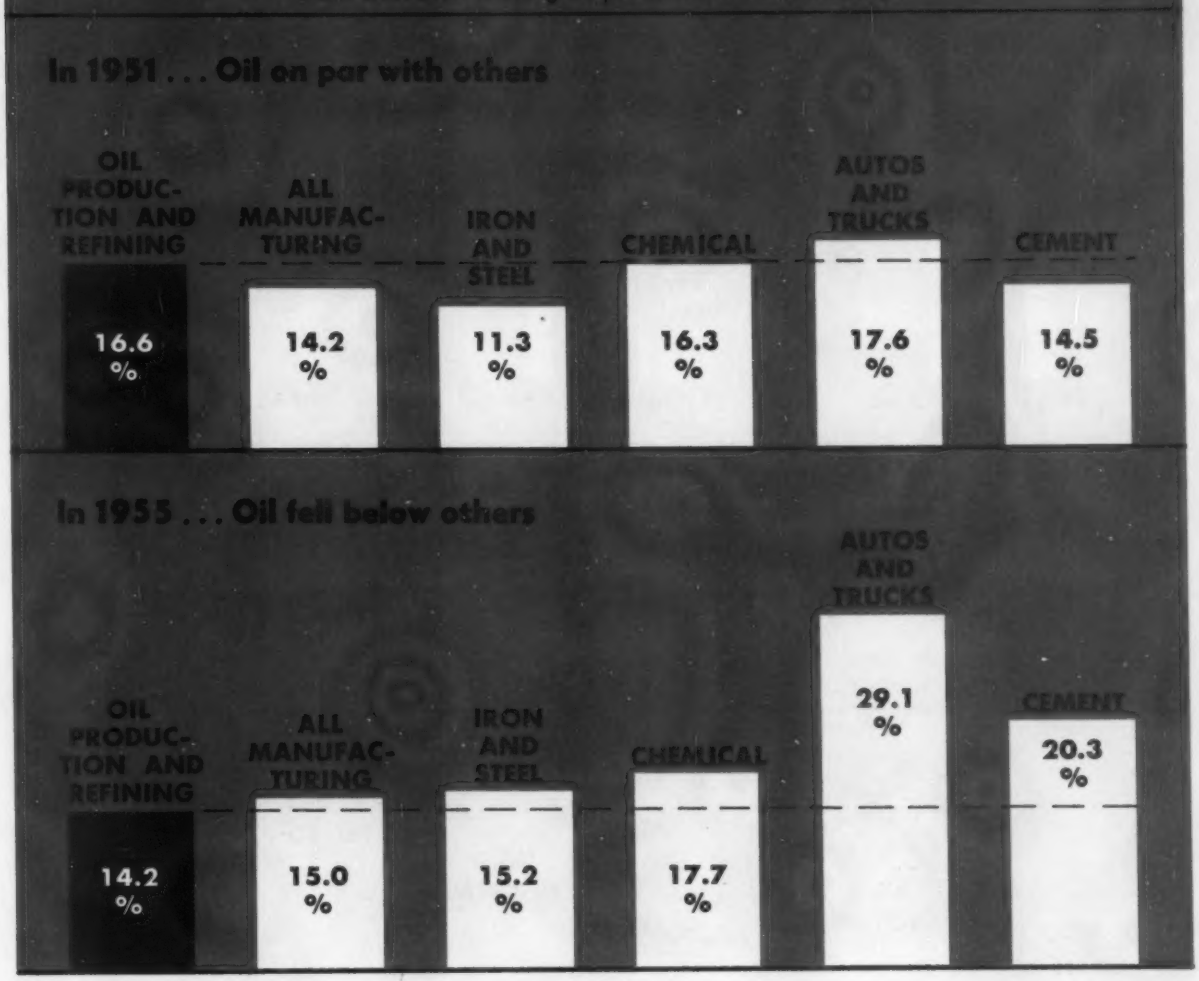
A particularly large increase in the cost of finding oil occurred between 1948 and 1956. A growth of 125 percent was recorded. This big gain was due to the increased number of wildcats drilled and the growing number of dry holes drilled, as well as higher wages and prices of casing and machinery.

Finding new producing fields is the industry's big risk—the operation that makes it different from any other business. Prices must be adequate to provide ample incentive, or men will not risk huge sums at 1-out-of-9 odds.

Unless wildcatting is maintained at high rates, the nation's oil producing ability would soon shrink below needs. The output of oil wells inevitably declines gradually as they become older. America's high consuming rate requires the discovery of over 4 billion barrels of new oil each year.

RATE OF RETURN ON CAPITAL INVESTMENT HIGHER IN OTHER INDUSTRIES THAN IN OIL

Source: First City National Bank of New York Monthly Letter.
Data based on leading corporations in each industry.



Oil is not the fabulously profitable business so many consider it to be. Many other businesses earn a higher rate of return on capital investment.

Furthermore, failure of oil prices to keep pace with rising costs has meant decreasing profit margins in recent years while returns of other industries have increased. The rate of return on investment by leading oil companies has never been out of line with that of other business and in recent years has been quite moderate in comparison with other industries.

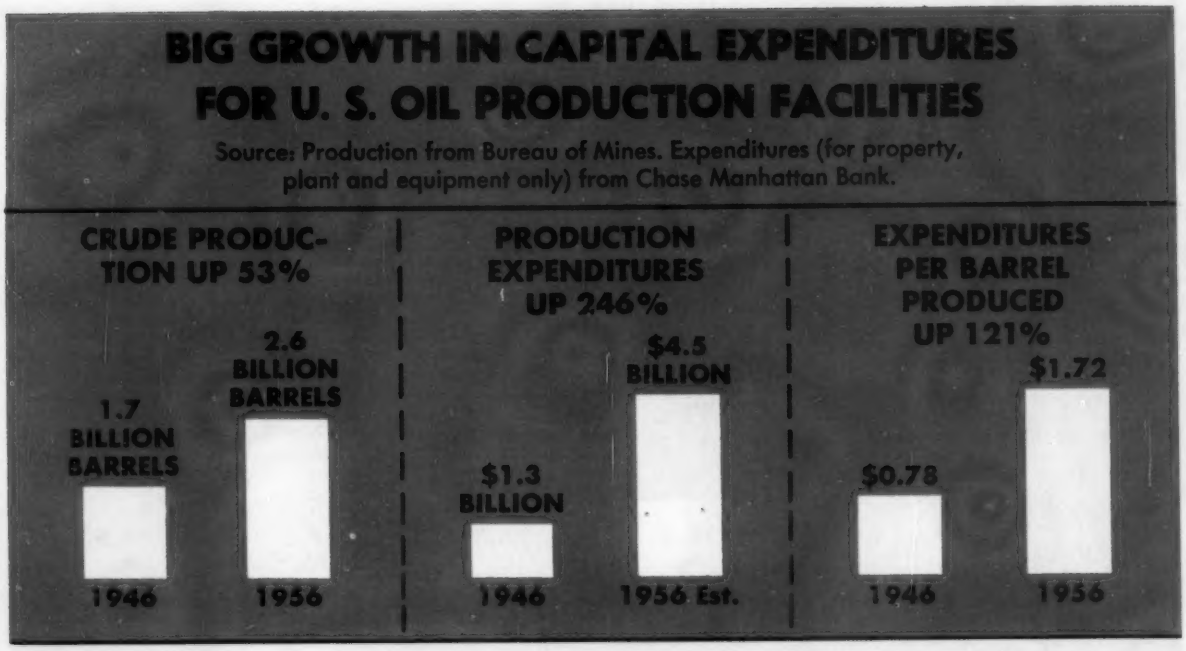
In net return on net assets the oil industry is behind such businesses as iron and steel, chemical products, motor vehicles, all manufacturing industries and others.

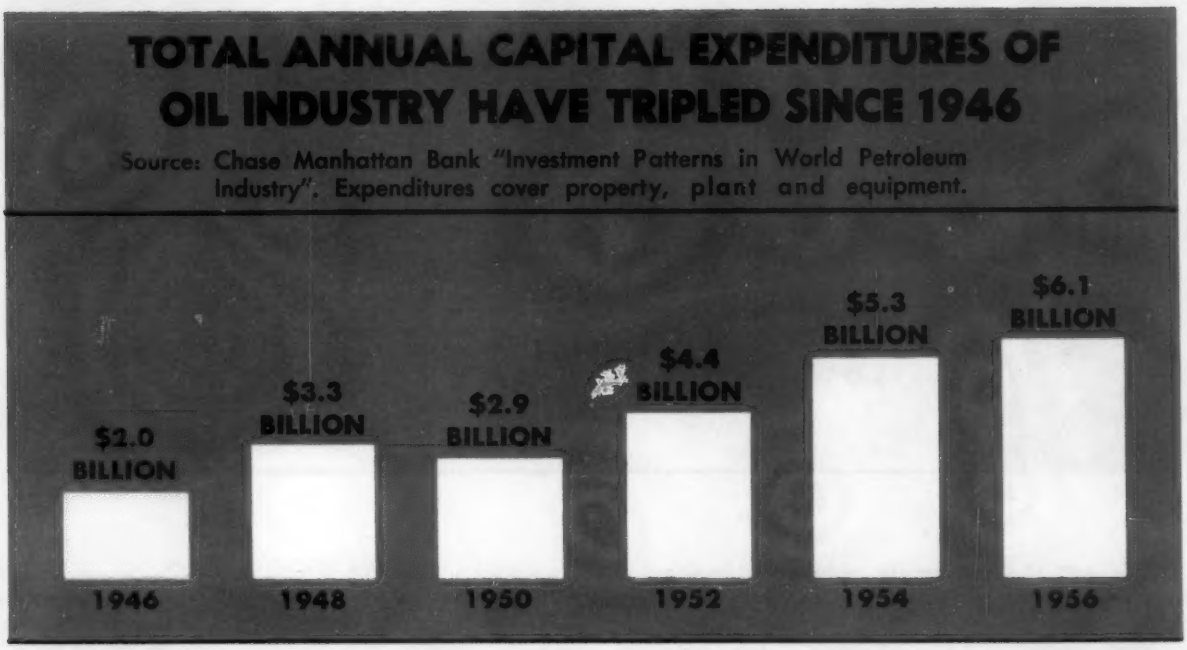
Ninety-two leading U. S. petroleum producing and refining corporations, including those with large foreign holdings as well as domestic, had a return of 14.2 percent on their net assets in 1955, latest year available. This compared with a 16.6 percent in 1951.

Rising costs without corresponding increases in prices have cut down net returns on oil investment. Because of greater risks in oil producing operations, the oil industry should enjoy higher rates of return than other businesses.

In contrast, manufacturing, iron and steel, chemicals, autos and trucks, cement and other industries had higher return rates on their investments in 1955 than in 1951. Some were up by substantial amounts. The automobile industry, for example, had a net return of 29.1 percent in 1955 compared with 17.6 percent in 1951.

Mr. and Mrs. America hear of the few oil men who are fortunate enough to hit a bonanza. But they never hear of the thousands of oil men who struggle throughout their lives to make ends meet, nor of those who lose vast sums of money hoping to find an oil field.





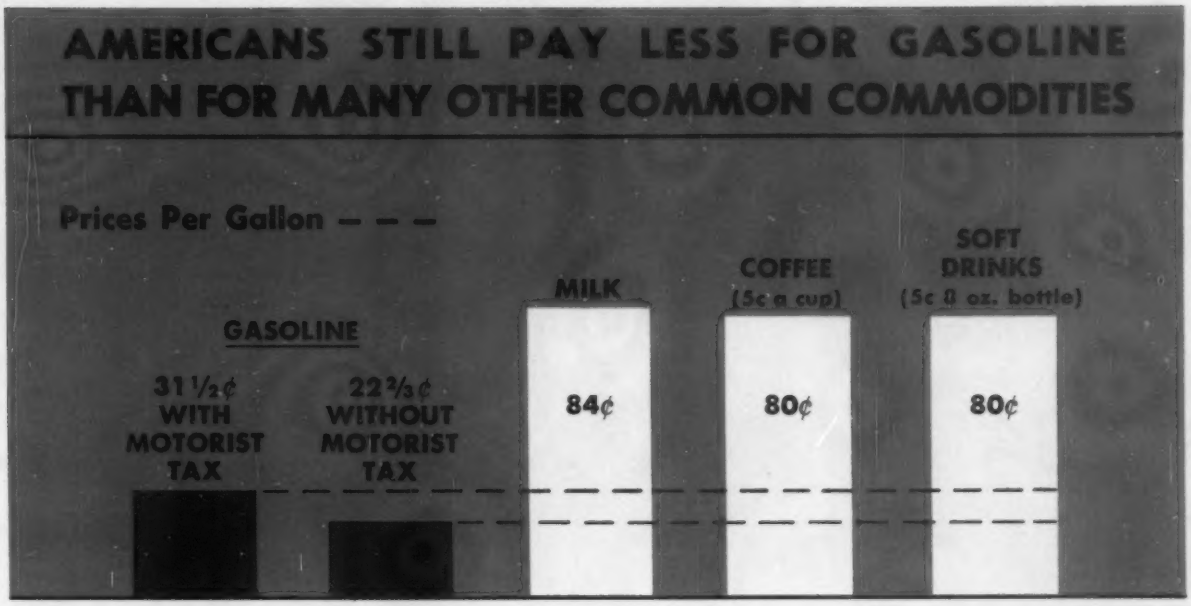
Oil is an extremely expensive business. Huge capital investment is required to provide enough oil to meet expanding U. S. civilian and industrial requirements.

Total annual petroleum capital expenditures in the U. S. (for property, plant and equipment only) have risen sharply in recent years. They reached the staggering sum of $6.1 billion during 1956, three times larger than in 1946. Most of this investment was in producing operations.

Since World War II capital investment in U. S. oil has totaled $44.2 billion. No other industry has matched this investment rate. Oil now ranks as one of the largest industrial activities in the nation.

It is highly important that oil have an adequate profit level. Chase Manhattan Bank has estimated $51 billion will need to be invested during the next ten years to keep America supplied with oil. There would be no hope that a sum of such magnitude could be generated internally or be attracted from outside investors unless the industry's prices keep pace with rising costs.

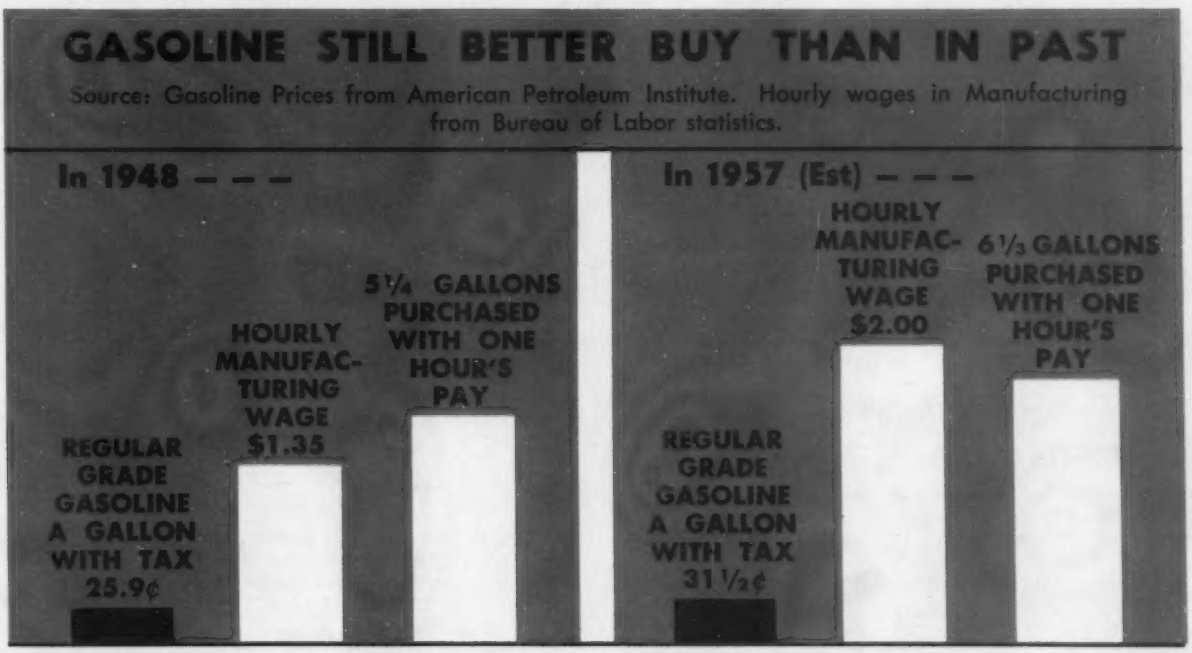
The recent Suez crisis has demonstrated dramatically that adequate domestic oil supplies are vital to America's security. America must have oil. It operates on oil.



Gasoline Is Still Cheap. It is still America's biggest bargain. Such items as milk, coffee and soft drinks retail for about 2½ times more than gasoline. This is true today, even after the recent gasoline price advance.

Mr. and Mrs. America pay an average of 31½ cents a gallon for regular grade gasoline today. However, state and federal motorist taxes make up nearly 9 cents of this amount. But even with taxes included, gasoline is cheap, costing only 2 cents per mile traveled.

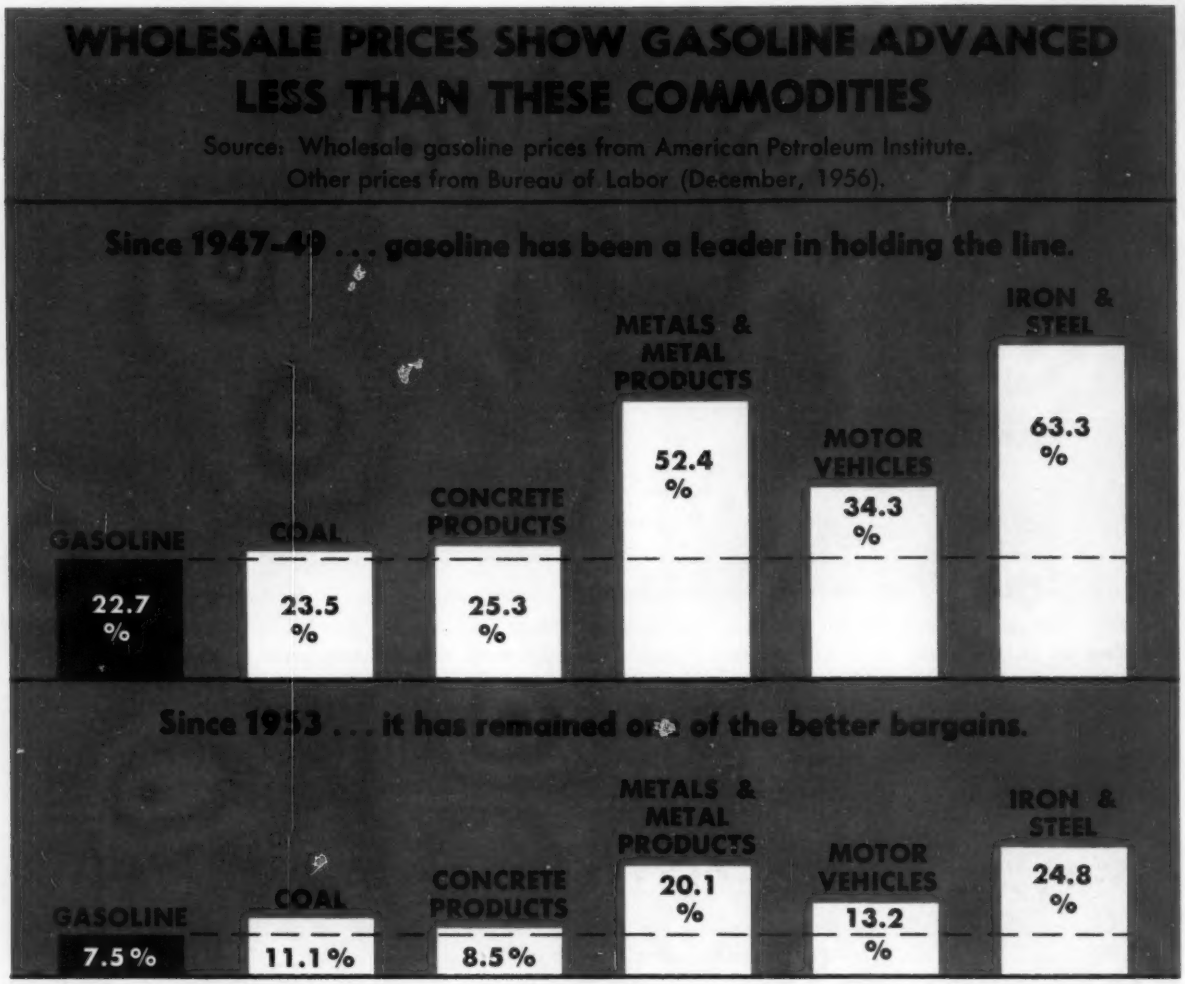
Gasoline weighs approximately 6 pounds a gallon, hence sells for 5⅓ cents per pound including taxes. What else sells for so little these days?


GASOLINE STILL BETTER BUY THAN IN PAST
Source: Gasoline Prices from American Petroleum Institute. Hourly wages in Manufacturing from Bureau of Labor statistics.
In 1948 — — —
REGULAR GRADE GASOLINE A GALLON WITH TAX 25.9¢
HOURLY MANUFACTURING WAGE $1.35
5¼ GALLONS PURCHASED WITH ONE HOUR'S PAY
In 1957 (Est) — — —
REGULAR GRADE GASOLINE A GALLON WITH TAX 31½¢
HOURLY MANUFACTURING WAGE $2.00
6⅓ GALLONS PURCHASED WITH ONE HOUR'S PAY

Gasoline takes a smaller portion of U. S. workers' pay today than in the past. More gasoline can be bought today with an hour's pay. Furthermore, the quality of gasoline is far superior to earlier years.

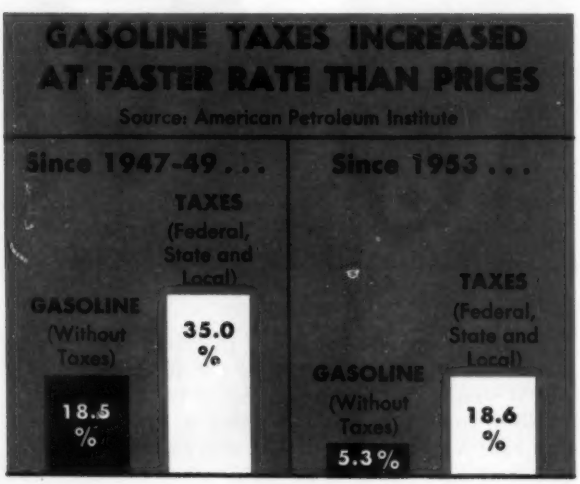
The average hourly wage of manufacturing employes, for example, will buy 6⅓ gallons of gasoline in 1957. Their hourly pay in 1948 would purchase only 5¼ gallons. These costs include all state and federal taxes.

If it were not for high motorist taxes, manufacturing employes could buy nearly 9 gallons of gasoline in 1957 with each hour's pay in contrast with slightly less than 7 gallons in 1948.


WHOLESALE PRICES SHOW GASOLINE ADVANCED LESS THAN THESE COMMODITIES
Source: Wholesale gasoline prices from American Petroleum Institute.
Other prices from Bureau of Labor (December, 1956).
Since 1947-49 . . . gasoline has been a leader in holding the line.
GASOLINE 22.7 %
COAL 23.5 %
CONCRETE PRODUCTS 25.3 %
METALS & METAL PRODUCTS 52.4 %
MOTOR VEHICLES 34.3 %
IRON & STEEL 63.3 %
Since 1953 . . . it has remained one of the better bargains.
GASOLINE 7.5%
COAL 11.1%
CONCRETE PRODUCTS 8.5%
METALS & METAL PRODUCTS 20.1 %
MOTOR VEHICLES 13.2 %
IRON & STEEL 24.8 %

Gasoline prices have risen less than most commodities. After the recent increase, wholesale gasoline prices are 22.7 percent above the 1947-1949 average, and 7½ percent above 1953. Few other commodities outside of farm products have had so small an increase.

Taxes have grown faster than the retail price of gasoline. Without taxes, retail gasoline prices are only 18.5 percent above the 1947-1949 average, while taxes are up 35.0 percent. Nevertheless, gasoline is still one of the biggest bargains in America today.


GASOLINE TAXES INCREASED AT FASTER RATE THAN PRICES
Source: American Petroleum Institute
Since 1947-49 . . .
GASOLINE (Without Taxes) 18.5 %
TAXES (Federal, State and Local) 35.0 %
Since 1953 . . .
GASOLINE (Without Taxes) 5.3%
TAXES (Federal, State and Local) 18.6 %

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As a service to the oil industry, reprints of this report are being made available at the following prices: Quantities under 100—10 cents each; Quantities from 100 to 1000—7½ cents each, and in quantities over 1000—5 cents each. Send your order and remittance to:

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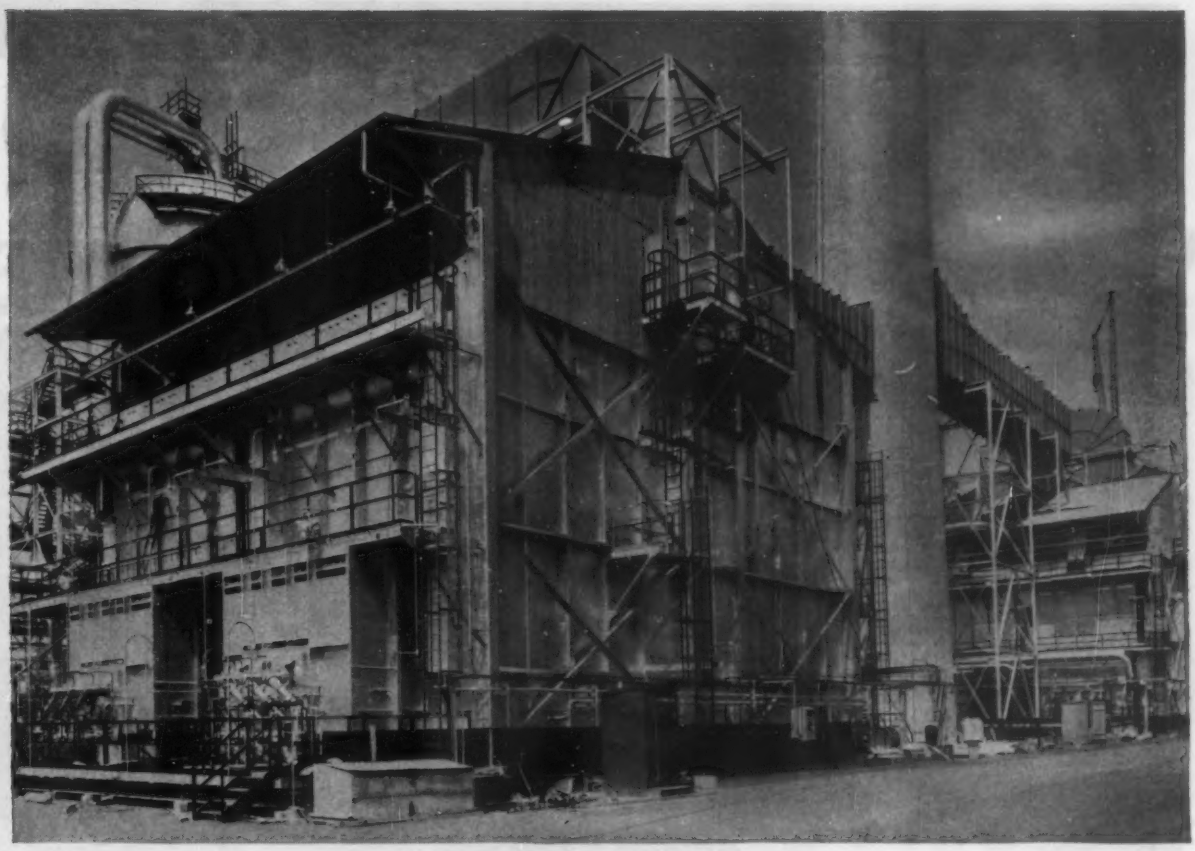


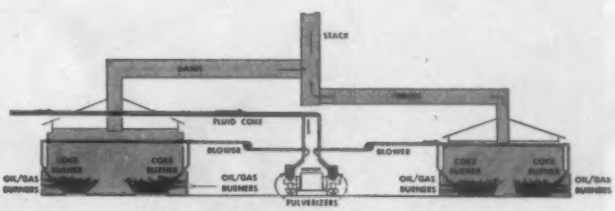
357,000,000 btu/hr

from two FW direct-fired oil heaters designed to burn FLUID COKE

SUPPLYING the heat requirements of the world's highest capacity crude distillation unit at the new ultra-modern Delaware Flying A Refinery of Tidewater Oil Company, the two Foster Wheeler direct-fired oil heaters shown above have a heat absorption capacity of 357 million btu per hr. The petroleum industry's first direct-fired heaters designed to burn fluid coke, they are capable of heating 130,000 bbl of crude per day.

Fluid coke can be burned at the rate of approximately 220 tons per day, supplying one half of the total direct heat requirements when operating at full capacity. Fuel oil or gas burning will supply the other half.

This installation is another example of Foster Wheeler's ability to design and construct direct-fired heaters of exceptionally high heat-duty requirements. This specialized



experience can help you save time and expense in meeting your exact requirements for special heating and vaporization units. For full details on the 357,000,000 btu/hr units above, send for the Nov.-Dec. Heat Engineering. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

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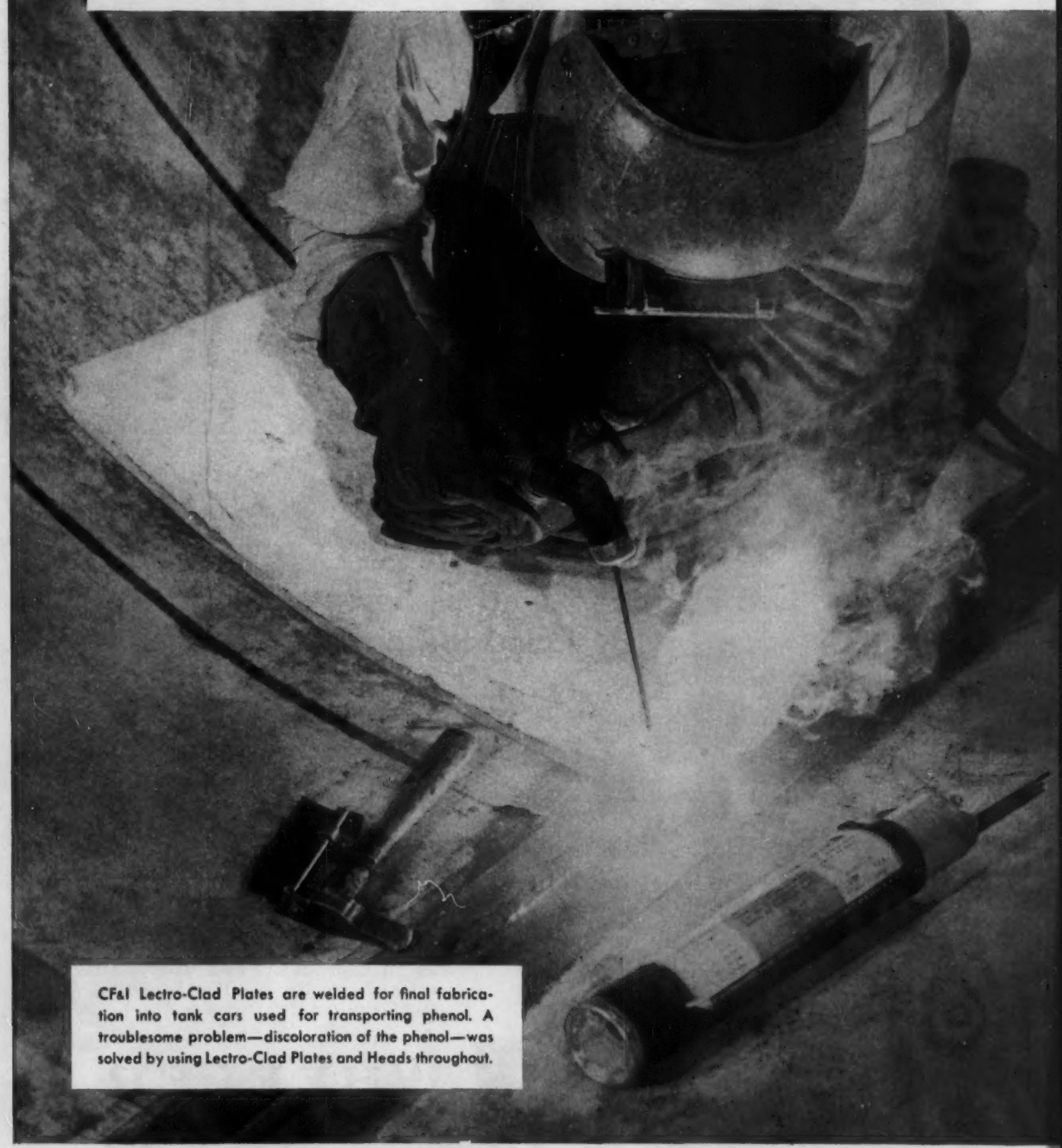
For more data on advertised products, use Readers' Service Cards, last page.

CF&I LECTRO-CLAD* nickel's protection

TRADEMARK



CF&I Lectro-Clad Plates are welded for final fabrication into tank cars used for transporting phenol. A troublesome problem—discoloration of the phenol—was solved by using Lectro-Clad Plates and Heads throughout.

PLATES offer you... plus 6-8 week availability

Stop waiting months for delivery on nickel and nickel-clad plates! Switch to CF&I Lectro-Clad Nickel Plated Steel. Smart fabricators and end-users all over America are finding that this dependable product successfully combines the protection of nickel and the economy and strength of carbon steel. AND CF&I LECTRO-CLAD NICKEL PLATED STEEL PLATES ARE AVAILABLE WITHIN 6 TO 8 WEEKS!

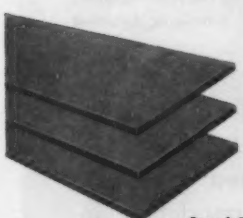
CF&I Lectro-Clad Plates and Heads are now being used successfully in many transportation and storage applications where product contamination or discoloration is a problem. They are also effective for processing applications where the corrosion rate does not exceed .0015 inches per year. CF&I Lectro-Clad is customarily supplied with 8-10 mil nickel plating; however, it can be plated up to 28-30 mils if specified.

CF&I Lectro-Clad is easy to fabricate. It can be worked with regular shop equipment. Bend it . . . weld it . . . roll it . . . the protective nickel layer stays firmly bonded to the steel. It will not check, spall or flake.

Delivery time on this 8-foot diameter caustic evaporator was reduced by one full year when its fabricator switched to CF&I Lectro-Clad. Plate used was ⅜" steel with a 15 mil layer of nickel. Heads were also fabricated from Lectro-Clad.

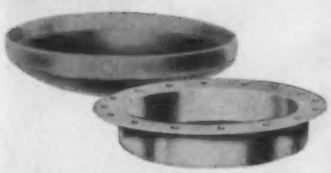
For the complete story on Lectro-Clad, ask for the Lectro-Clad Nickel Plated Steel Technical Manual. Contact our nearest sales office or write us direct. Wickwire Spencer Steel Division, The Colorado Fuel and Iron Corporation, P. O. Box 1951, Wilmington, Delaware.

OTHER CLAYMONT PRODUCTS



Steel Plates
Alloy • Stainless Clad
High Strength Low Alloy

Fabricated Steel Parts



Flanged and Dished Heads
Manhole Fittings and Covers

Large Diameter Welded Steel Pipe

CF&I

Claymont Steel Products

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***NICKEL PLATED BY THE BART LECTRO-CLAD PROCESS**

4338

Wagner TRANSFORMERS...THE CHOICE OF LEADERS IN INDUSTRY

Where uninterrupted power is a must...

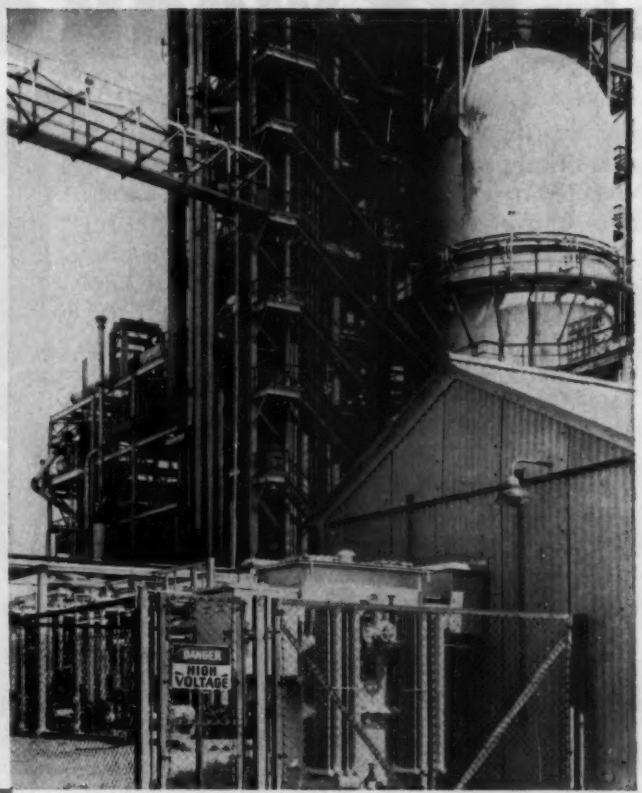
WAGNER UNIT SUBSTATION TRANSFORMERS

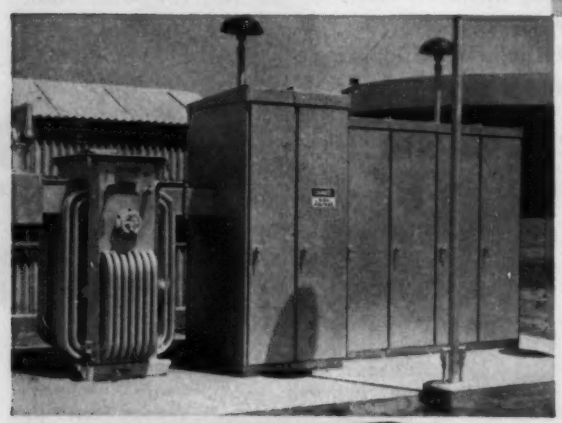
A completely dependable power supply is a vital necessity to an oil refinery. A power interruption of only a few minutes on a "cat cracker," like the one shown at the right, would completely disrupt this important processing operation and cause a shut-down of the entire refinery.

That's why you'll find Wagner Unit Substation Transformers at work at the Carter Oil Company refinery at Billings, Montana.

Wagner transformers are often found in installations where power supply failure would incur great loss because they have a reputation for complete dependability—backed by sixty-five years of transformer building experience.

Wagner Unit Substation Transformers, both liquid-filled and dry-type, are carefully designed to meet distribution requirements. Both liquid-filled and dry-type unit substation transformers are built in ratings through 2000 kva, 15 kv and below—you can choose the type and rating that exactly meets your load-center distribution requirements. Call the nearest of our 32 branch offices, or write us.





The 750 kva, 2400/4160Y to 480 volt, 60 cycle, three-phase, liquid-filled Wagner Unit Substation Transformer feeds the catalytic unit at The Carter Oil Company refinery. At left is shown a 225 kva Wagner substation transformer connected to an outdoor substation at the same refinery. Purchased and installed by The Fluor Corporation, Ltd., Engineers and Constructors for the Petroleum, Chemical and Power Industries, Los Angeles.

* * *

Write for Bulletins TU-205 and TU-214. They give full information on Wagner Unit Substation Transformers. Consult the nearest of our 32 branch offices about your next transformer installation.

Wagner Electric Corporation
EST. 1891

Wagner Electric Corporation
6458 Plymouth Ave., St. Louis 14, Mo., U.S.A.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

W756-9

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

Buy the one tube steel with the longest tube life per dollar: *Ask the experts!*

THE Timken Company makes 23 different high-temperature tube steels to help you solve your heat, pressure, corrosion and oxidation problems. But only *one* analysis really fits your particular needs, gives you maximum tube life per dollar—your best life/cost ratio. To find this *one,* right analysis, *ask the experts!*

Timken Company metallurgists are recognized authorities on high-temperature steels. They have over 20 years of experience backing them up. They'll put this experience to work for you, study your specific requirements, recommend the *one* tube steel that fits them—most economically.

You can be sure, too, that the analysis of Timken® steel you get will have uniform high quality. Because the Timken Company makes its own fine alloy electric furnace steels, it can maintain rigid quality control from melt shop through final inspection.

Timken Company metallurgists will be glad to help you solve your tube steel problems. Ask the experts! The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

This month's report is on:

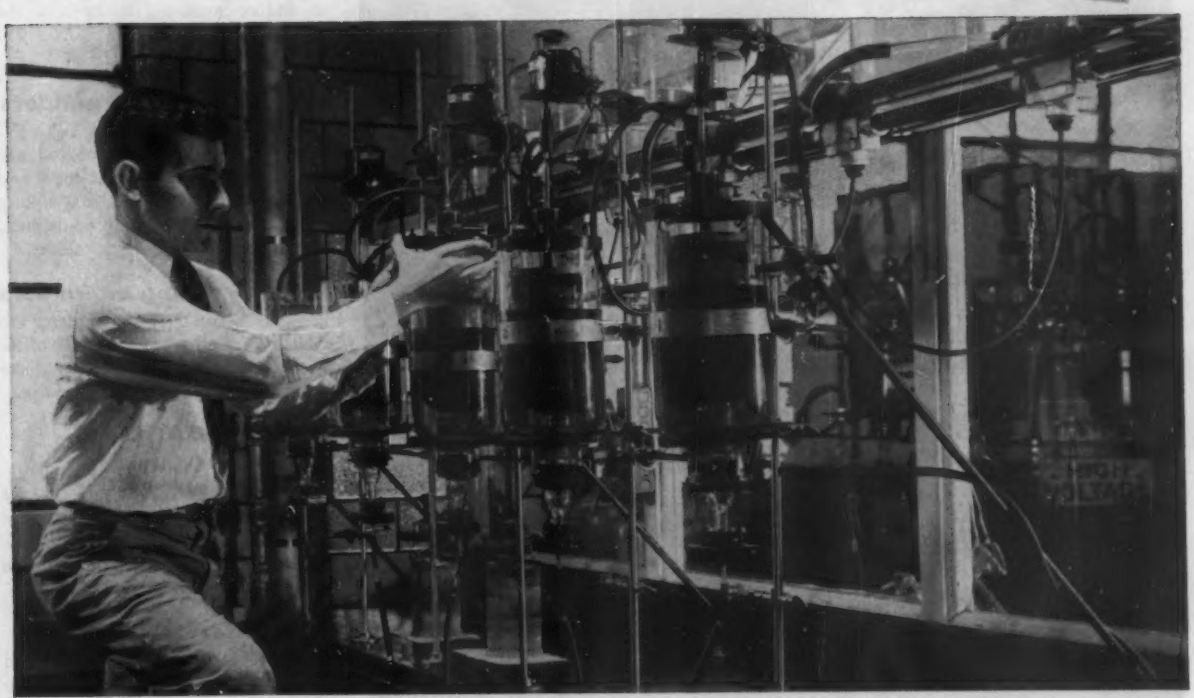
DM STEEL

Has unusually high creep strength for a pearlitic steel, good stability up to 1200°F., fairly good corrosion and oxidation resistance. Has 2 to 3 times the life of carbon steel where corrosion is not severe. Recommended for cracking furnace tubes, hot oil lines, superheater tubes, high temperature steam piping and forgings for accessory parts.

23 TIMKEN STEELS FOR HIGH TEMPERATURE SERVICE

Carbon	Sicromo 2	Sicromo 5S	16-13-3
Carbon-Mo.	Sicromo 2½	Sicromo 5MS	25-20
DM-2	2½% Cr.-1% Mo.	Sicromo 7	25-12
Silmo	Sicromo 3	Sicromo 9M	35-15*
DM	4-6% Cr.-Mo.	18-8 Stainless	16-25-6*
2% Cr.-Mo.	4-6% Cr.-Mo.-Ti.	18-8 Cb	

**Not available as seamless tubing at the present time.*



Special electrolytic extraction equipment helps separate inclusions, to give steel maximum cleanliness.

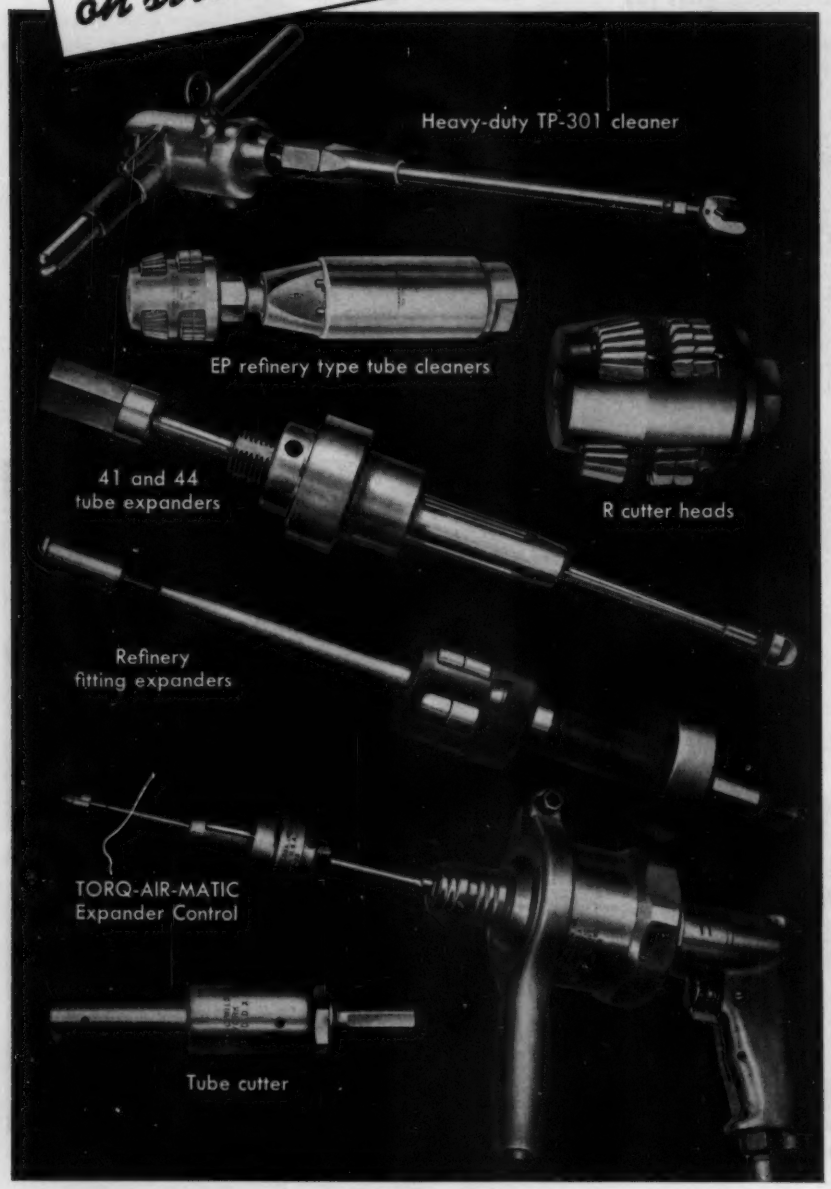
TIMKEN *Fine Alloy* STEEL

TRADE-MARK REG. U.S. PAT. OFF.

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

Keep tubular equipment on stream with...

WILSON
MAINTENANCE TOOLS



Heavy-duty TP-301 cleaner
Powerful air-driven, hollow rotary shaft, drill type tool. Tube is scavenged with air or water while cleaning.

EP refinery type tube cleaners
These heavy-duty "matched sets" are designed for rugged service in removal of heavy coke or scale deposits from still tubes, transfer lines, service pipe lines, etc.

R cutter heads
The Model R is a self-feeding, double expansion head, specifically designed to endure sustained abuse with the minimum of maintenance. Excellent for refinery still tubes.

41 and 44 tube expanders
Wilson Models 41 and 44 Tube Expanders incorporate an improved, adjustable ball bearing thrust collar and are designed for efficient, easy rolling and maximum roll length adjustment for various tube sheet thicknesses.

Refinery fitting expanders
Various heavy-duty expanders are available for all types and sizes of refinery fittings and tubes. Made of the best steel available for this purpose.

TORQ-AIR-MATIC Expander Control
The Wilson Torq-Air-Matic is the first and only air-driven tube expander drive that accurately controls tube expansion by directly measuring torque output at the mandrel.

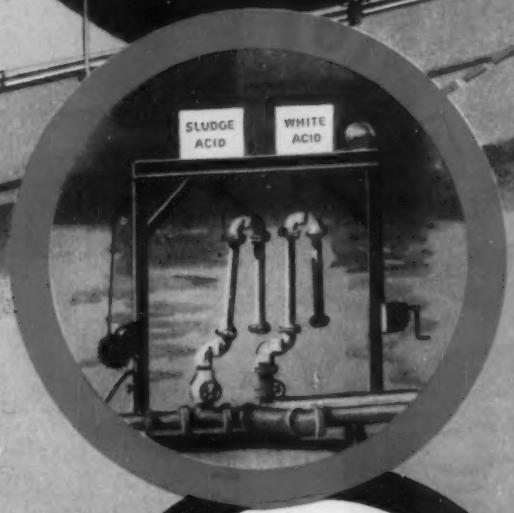
Tube cutter
Wilson tube cutter is easy to use and does a fast job. Just chuck it into existing drill. Cutter sizes available to meet all heat exchanger requirements.

Representatives in principal cities
THOMAS C. WILSON, INC. • 21-11 44th Ave., Long Island City 1, N. Y.
Cable address: "Tubeclean", New York

TW 873

WILSON
TUBE CLEANERS • TUBE EXPANDERS

Write today for your copies of Wilson Tube Cleaner catalog No. 77 and Wilson Tube Expander Catalog No. 88.



PROFIT FROM WASTE

with Consolidated's sludge acid regeneration service

ALL over the Southwest, refineries and petrochemical plants are turning a disposal problem into an asset by shipping their spent acids to one of Consolidated Chemical Industries' five sulphuric and recovery plants. Here even the heaviest sludges, with the lowest per cent of free acid, are turned into fresh, white 99% product on a contract basis. Shipments are handled by road, rail or water.

This acid regeneration service is in keeping with Consolidated's leadership in the manufacture of sulphuric acid and allied chemical raw materials. Whether your requirements are for a fast, dependable source of new acid or for a method of turning past waste into future profit, you can depend on CCI—the *big* name in sulphuric acid in the Gulf Southwest. Write for complete information.

Stauffer CHEMICALS SINCE 1885

CCI

CONSOLIDATED CHEMICAL INDUSTRIES

DIVISION OF STAUFFER CHEMICAL COMPANY

640 Esperson Building, Houston 2, Texas • 380 Madison Avenue, New York 17, N. Y.

WHAT'S SO GREAT ABOUT EYE SAVERS **SOFT VINYL FRAME** SAFETY GOGGLES?

If you checked all three, you scored 100%. If you need all three, you should check into Eye Savers SOFT VINYL FRAME safety goggles.

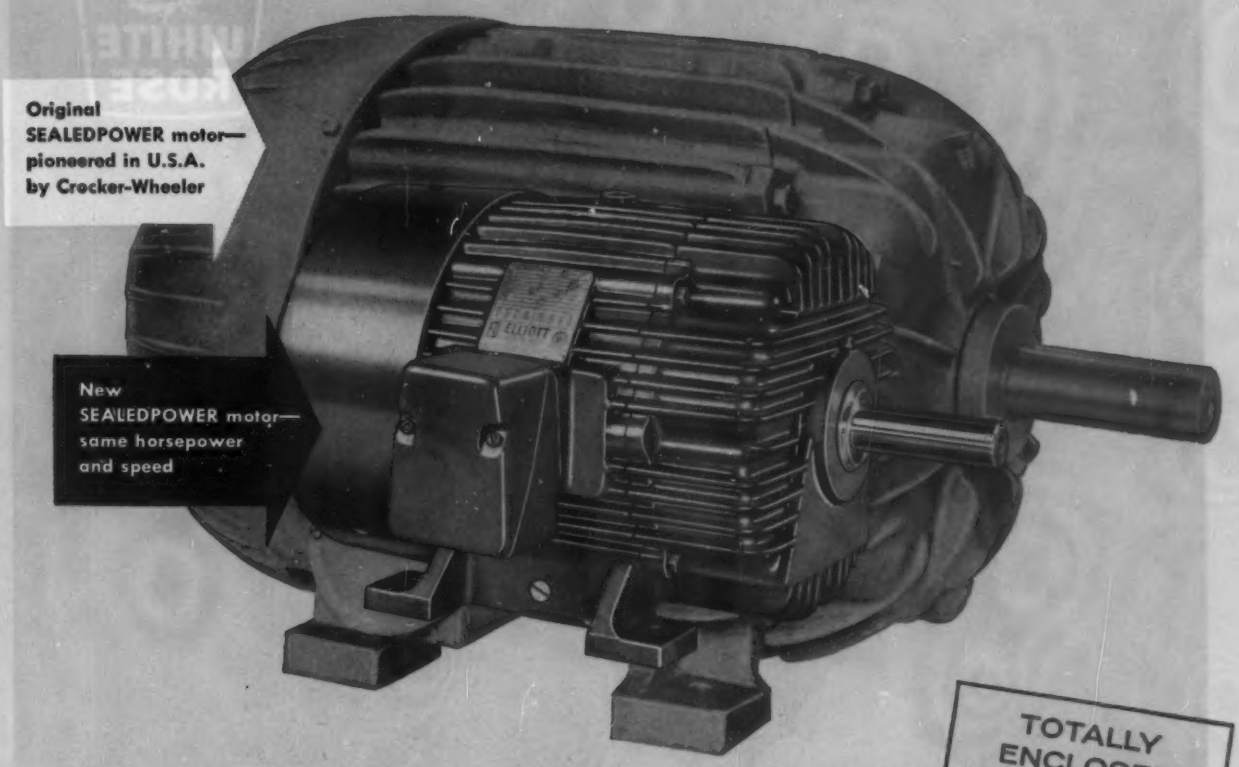
For details, see your Authorized Eye Savers Supplier or write direct

Quality Eye Protective Equipment *Made by the Leaders in Plastics*

WATCHEMOKET OPTICAL CO., INC.

232 WEST EXCHANGE ST., PROVIDENCE 3, R. I. *In Canada: Levitt-Safety Limited, Toronto 10, Montreal 26, Winnipeg*

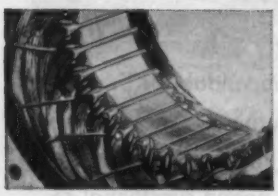
Inside and Outside . . . entirely new



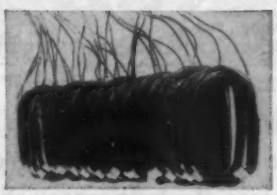
TOTALLY ENCLOSED FAN-COOLED FRAMES 284U-326U

NEW Elliott SEALEDPOWER Motors Produce MORE POWER per POUND

Superior Insulation Improves Motor Performance



Stator slots are lined with new, revolutionary synthetic materials having greater dielectric and mechanical strength than those previously used.



Motor coils are group-wound from continuous lengths of Vinylastic wire, with no brazed or soldered connections within groups.

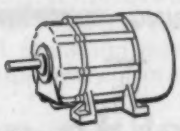
In the new Elliott Crocker-Wheeler Type N motors, better utilization of copper, insulation, and electrical steel produces more horsepower per pound than earlier designs.

This is one of the *balanced design* factors that contribute to the outstanding performance of these motors. Others are highest quality electric steel, rigid frames and brackets, choice of anti-friction bearings to suit your operating and maintenance conditions, and a variety of highly effective enclosures, including dripproof, totally-enclosed and explosion-proof designs.

OTHER C-W TYPE N MOTOR ENCLOSURES

Totally-enclosed non-ventilated

Dripproof Protected



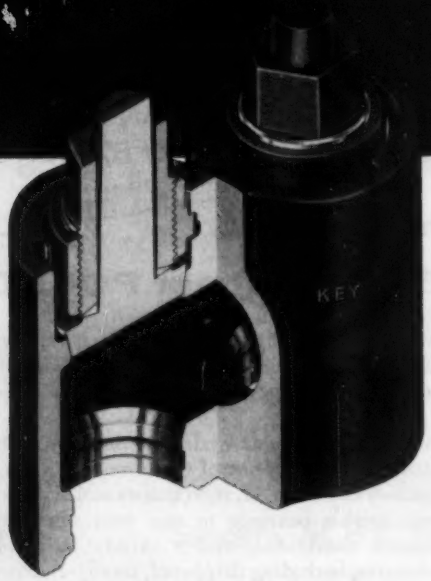
Totally-enclosed, fan-cooled Frames 256 U and smaller

ELLIOTT Company

CROCKER-WHEELER DIVISION

***WRITE* for new bulletin describing Elliott C-W Type N Motors. *Address:* Elliott Company, Crocker-Wheeler Division, Jeannette, Penna.**

W6-7



another major refinery installs new KEY® 5000 type fittings

Canadian Oil Companies' refinery at Sarnia, Ontario, like so many others, has chosen dependable KEY 5000 Type Return Bend Fittings for its furnaces. These simply constructed, rugged fittings, with a minimum of parts and high degree of interchangeability, permit substantial reduction in inventory space and cost.

Write today for complete information on the new KEY 5000 Type Fitting. All parts, except body castings, are available in stock for immediate shipment.

W-K-M
DIVISION OF acf INDUSTRIES INCORPORATED
Plant: Missouri City, Texas • Mailing Address: P.O. Box 2117, Houston, Texas

MANUFACTURING

KEY RETURN BENDS AND FITTINGS

W-K-M THROUGH-CONDUIT GATE VALVES

acf LUBRICATED PLUG VALVES

Standard tries a flood of fire to make worn out oil fields produce again

Fire flooding produces heat and pressure to boil out previously unrecoverable crude oil, driving it underground to nearby producing wells.

MANY INACTIVE WELLS STILL HAVE LOTS OF OIL left underground in spite of the industry's great advances in oil recovery. Our country must have this oil to meet the growing power needs of industry, the Armed Forces and motorists. That's why Standard is trying a new conservation experiment called "fire flooding."

We ignite some of the oil in a pool . . . control burning by regulating the air supply. Heat and pressure drive the oil to surrounding wells for pumping. It will take more than a year's time and a million dollars to see if fire flooding works. It's worth the effort because it could add more to U.S. underground oil reserves than the discovery of an entire new oil field.

Progress in the West means...

Helping find new sources of oil to supply the 13 million barrels per day the U.S. will need in 1966

1956	1966
8,827,000 barrels per day	13,000,000 barrels per day

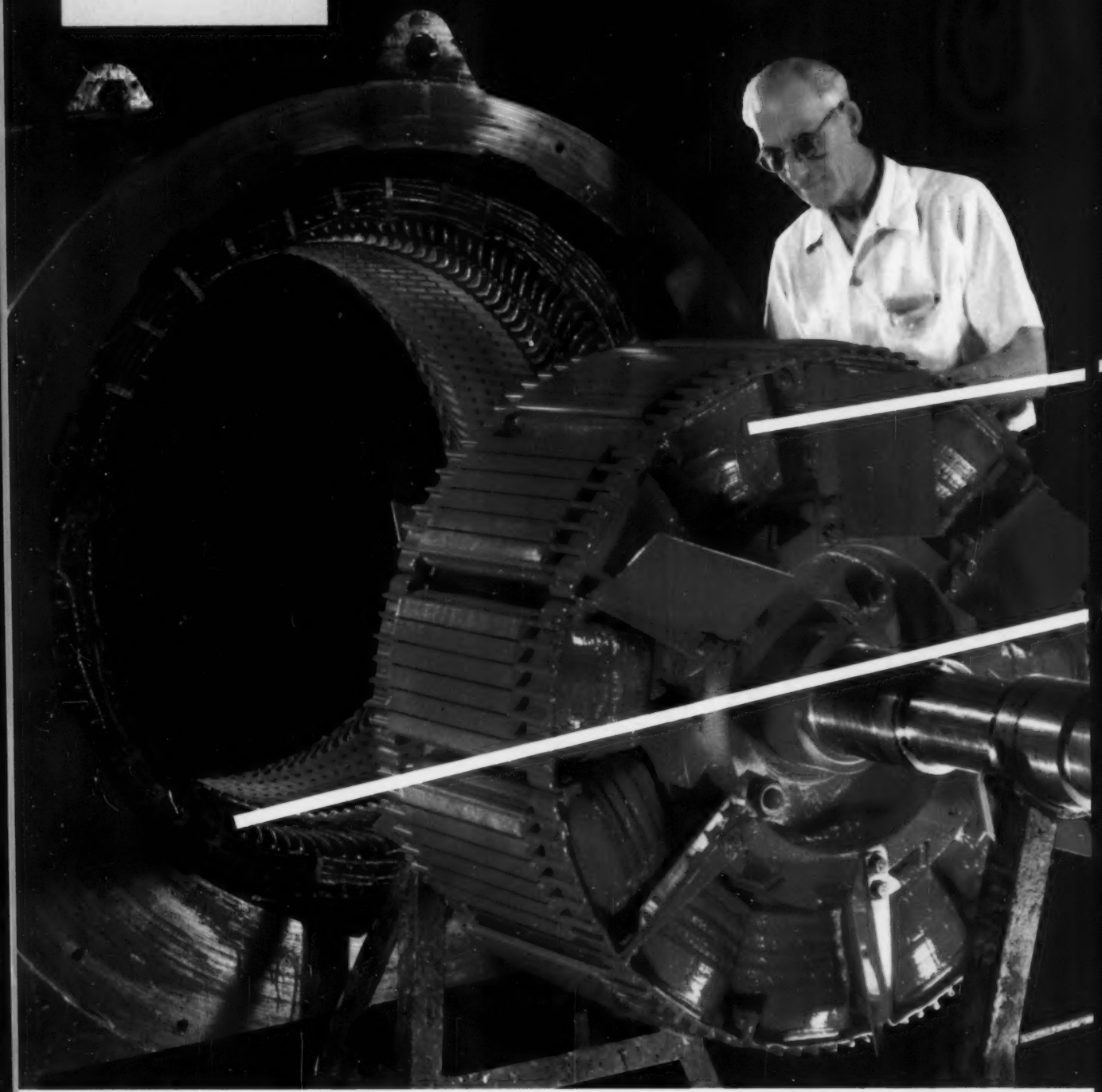
Standard's petroleum engineers say, "Back in 1925 the industry could predict only about 20% recovery from a new field. Modern secondary recovery methods, of which fire flooding is one of the latest, could more than double recovery."

STANDARD OIL COMPANY OF CALIFORNIA

plans ahead to serve you better

For more data on advertised products, use Readers' Service Cards, last page.

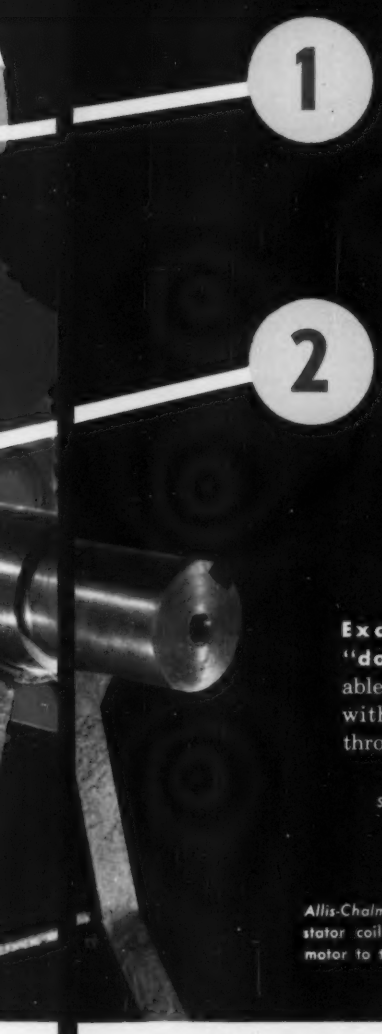
ONLY Allis-Chalmers



ALLIS-

MOTORS are "double protected"

New Integrated Field Coils Plus *Silco-Flex* Stator Insulation Provide Superior Motor Protection . . . Under Any Operating Conditions



1

Integrated Field Coils are bonded in heat-stabilized resins, enclosed in a resin-impregnated sheath of oriented glass fibers and bond-locked on the pole structure . . . dimensionally stable to withstand heating and thermal shock, vibration and fatigue at elevated temperatures . . . sealed throughout against atmospheric contaminants and fully protected against destructive forces.

2

***Silco-Flex* Insulation** provides a homogeneous, void-free insulating wall of silicone rubber on stator coils. It is unexcelled in life and thermal stability at high temperatures . . . resistant to most chemicals, water, weather . . . outstanding in flexibility and resilience . . . able to withstand abrasion and corona . . . resistant to physical and mechanical forces.

Exclusive Allis-Chalmers "double protection" is available on large electrical machines with operating temperatures through Class B range.

Silco-Flex is an Allis-Chalmers trademark.

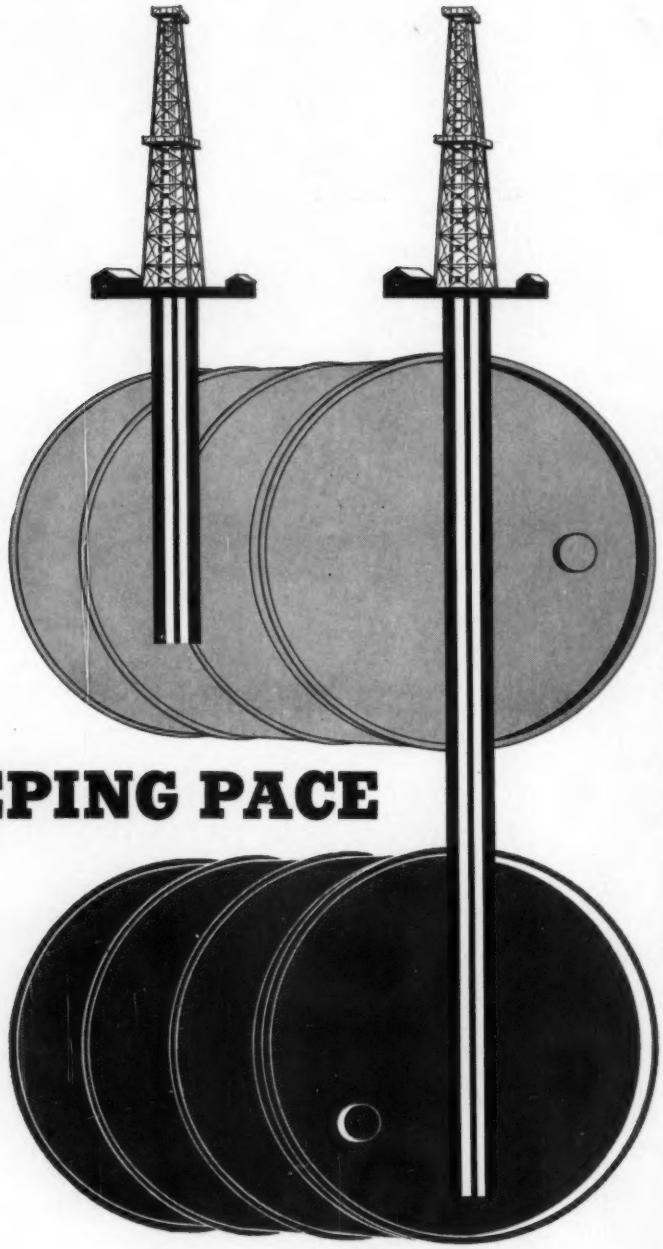
For more information on these quality insulation systems contact your nearby A-C office, or write Allis-Chalmers, Power Equipment Division, Milwaukee 1, Wisconsin for Integrated Field Coil Bulletin 05R8525 and *Silco-Flex* Insulation Bulletin 05R8341.

Allis-Chalmers "Double" Protection," with integrated field coils and Silco-Flex stator coil insulation, adapts this 600-hp, 2300-volt, 600-rpm synchronous motor to the most severe operating conditions.

CHALMERS

A-C ALLIS-CHALMERS

A-5221



KEEPING PACE

Drills were chewing their way down for about 2000 feet in the search for oil in 1916. Today's drilling depth is more than double that.

The change in drilling that forty years has brought well symbolizes many advances in the petroleum and chemical industries. Engineers have dug more deeply into the secrets of nature, too . . . have designed plants and processes to wrest new products and services from petroleum, ores and elements.

We mentioned 1916 because that is the year Sun Ship was founded. It has long served the swift-growing needs of petroleum and chemical industries. Year by year, the engineering skill and facilities of the great Sun Ship plant have proven their ability to meet the demands for plant and equipment keyed to the swift pace of progress in these and other important fields. Sun Ship keeps pace with progress.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

"Personally,
I always specify
LEWIN-MATHES
Condenser Tube"

Lewin-Mathes welcomes stiff-necked specifications.

We meet them... because, as COPPER REFINERS, we control the exact composition of every alloy billet we form into condenser tube.

We meet them . . . because, as FABRICATORS, we control every step in the manufacture of Lewin-Mathes Condenser Tube from *raw material to finished product.*

We meet them . . . because, as INTEGRATED SPECIALISTS, we take pride in delivering every foot of Lewin-Mathes Condenser Tube uniform and perfect . . . "tailor-made" to perform better under *your* specific operating conditions.

Lewin-Mathes' mastery over every physical and chemical property of Heat Exchanger Tube can mean important savings for you. Bring your condenser tubing problems to us and see!

Nothing primitive about Lewin-Mathes service facilities. Expert technical and engineering assistance is available to you through 25 strategically-located Branch Offices.

LEWIN MATHES
SAINT LOUIS, MISSOURI
CUPRO-NICKEL CONDENSER TUBE
COPPER AND BRASS TUBE, PIPE AND ROD

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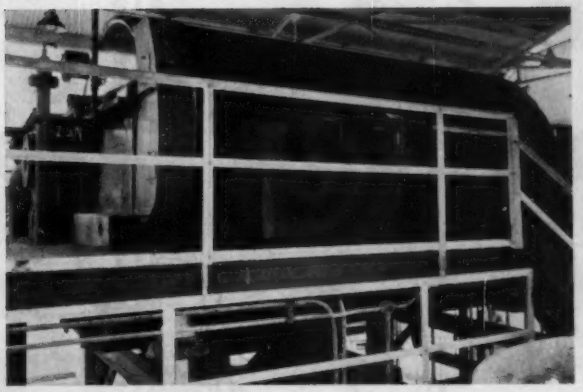
Breaking slop oil emulsions...

a natural for

The OLIVER PRECOAT FILTER



General view of the Oliver Precoat Station

Closeup of knife edge discharger clearly showing thin film of precoat and cake being continuously removed.

Recently installed at a large Southwestern Refinery, is another Oliver Precoat Filter for the handling of refinery slop oils.

The problem . . . continuous and economical removal of colloidal solids such as clay, coke, carbon, catalyst and some chemical emulsifiers from refinery slop oils thus permitting the separation of oil and water.

The Oliver Precoat Filter handles this heretofore considered "difficult to filter" material and delivers a filtrate which readily separates into oil and water phases.

Dorr-Oliver manufactures a complete line of filters — batch and continuous, for the petroleum industry. For more information on Oliver Petroleum Filters, write Dorr-Oliver Incorporated, Stamford, Conn.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U.S.A.

NO LEAKAGE
NO CONTAMINATION
NO STUFFING BOX

Lapp PULSAFEEDER CONTROLLED-VOLUME CHEMICAL PUMP

Lapp Pulsafeeder is a combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only a hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from the working pump parts—eliminates need for stuffing box or running seal. Pumping speed is constant; variable flow results from variation in piston-stroke length—controlled manually by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 535 Wilson St., Le Roy, N.Y.*

Lapp

For more data on advertised products, use Readers' Service Cards, last page.

GARLOCK and Announce

THE COMPLETE INTEGRATION OF THEIR SALES FORCES

Now, the United States Gasket Company will be known as the United States Gasket Company, Plastics Division of The Garlock Packing Company.

In August 1955 Garlock acquired the United States Gasket Company. Subsequently, the production facilities of both companies were integrated. Now, it is clear that the customers of both companies will be better served through an integrated sales force.

Better Service for Customers

Both U.S.G. and Garlock customers will now enjoy the finest, most complete service available in the fields of fluorocarbons (Teflon* and Kel-F**), nylon and other plastics as well as mechanical packings and seals of all types. Specialists in specific materials and applications will always be available for consultation on your problems.

Saves You Time

This integration of sales forces will also simplify your purchasing problem . . . you can standardize on one reliable source of supply and have more time to devote to other important problems.

Unbiased Recommendations

With the addition of U.S.G. plastic products to the famous "Garlock 2,000" family of packings, gaskets, and seals, your local representative is able to supply the right seal for every conceivable need. Call him at the office nearest you.

30 Sales Offices

U.S.G. plastics specialists join the 125 Garlock salesmen at 30 sales offices and warehouses where large stocks of plastic products are stored. This means faster deliveries from local stocks, as well as expert plastics and sealing assistance as close as your telephone.

*DuPont Trademark
**M.W. Kellogg Trademark

Main Factory Buildings of The Garlock Packing Company, Palmyra, New York. Other factories in San Francisco and Canada.

One of the two Camden, N.J. plants of the United States Gasket Company, Plastics Division of The Garlock Packing Company

United States Gasket

UNITED STATES DISTRICT OFFICES AND WAREHOUSES

Baltimore 18, Md., *2828 Lock Raven Rd.*
Birmingham 1, Ala., . . . *519 S. 19th St.*
Boston 10, Mass., ... *80 Broad St.*
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Chicago 6, Ill., . . . *600 W. Jackson Blvd.*
Cincinnati 16, Ohio, ... *8329 Vine St.*
Cleveland 13, Ohio, . . *1276 W. Third St.*
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Detroit 11, Mich., . *2781 E. Grand Blvd.*
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Pittsburgh 22, Pa., ... *933 Penn Ave.*
Portland 9, Ore., . . *1036 N.W. 18th Ave.*
Salt Lake City 1, Utah, *322 Dooly Bldg.*
San Francisco 7, Calif., *750 — 18th St.*
St. Louis 8, Mo., *3635 Forest Park Blvd.*
Seattle 4, Wash., ... *814 Lane St.*
Spokane 4, Wash., . . *W. 610 Second Ave.*
Tulsa 20, Okla., *316 E. 6th St.*

CANADIAN OFFICES AND WAREHOUSES

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Hamilton, Ont., ... *200 Queen St.*
Montreal 9, Que., *5214 De La Savane St.*
Toronto 2, Ont., ... *750 Bay St.*
Vancouver 5, B.C., *1925 W. Georgia St.*
Winnipeg 3, Man., ... *1436 Erin St.*

SPECIALIZED PLASTICS PRODUCTS FACILITIES AT U.S.G.

Three completely equipped laboratories—electrical, chemical and physical—are staffed by top-flight research, production and development engineers.

One of many extruders for TEFLON, KEL-F and nylon rods, tubes and special shapes.

Giant presses cold mold TEFLON sheets up to 48" x 48" in size, ready for sintering.

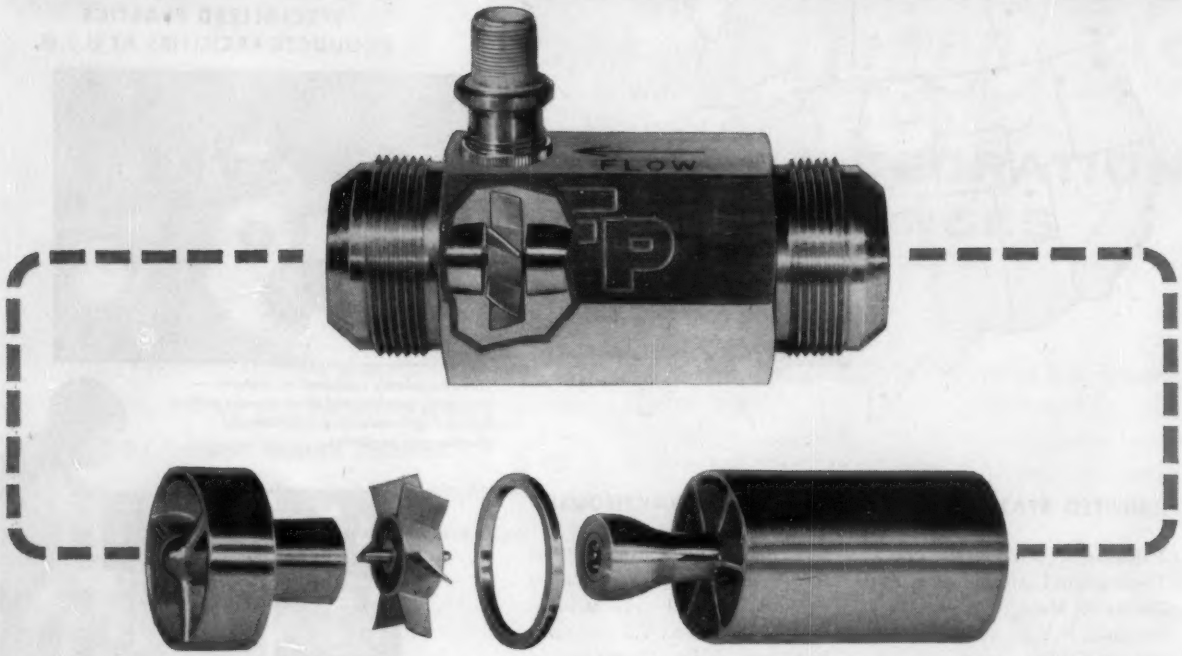
High product, low-cost injection molding of thermoplastic parts to manufacturers specifications.

GARLOCK

Packings, Gaskets, Oil Seals, Mechanical Seals, Rubber Expansion Joints, Fluorocarbon Products

For more data on advertised products, use Readers' Service Cards, last page.

The big difference is inside the NEW F&P TURBINE METER



NOW AVAILABLE TO YOU is the new F&P Turbine Meter—made to the same high standards that has made Fischer & Porter a world leader in flow measurement know-how.

Also from F&P you can secure a complete line of electronic digital and analog readout instruments, associated data handling instrumentation and unsurpassed calibration facilities—making the application of F&P Turbine Meter practical—dependable and easy to integrate into systems operation.

Inherent precision accuracy.

Unaffected by piping or orientation.

Easily disassembled and re-assembled with no shift in calibration.

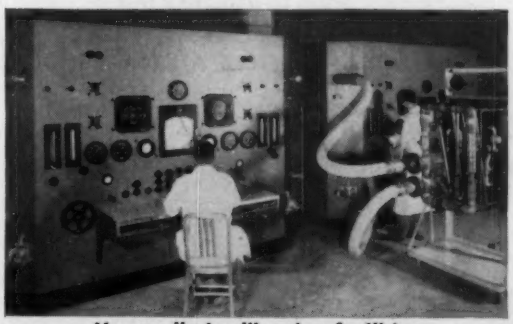
Wide-linear flow range.

Digital output proportional to flow.

Interchangeable calibration factors within size.

Low inertia for excellent transient response.

Write today for complete information on the F&P Turbine Meter. Test it in your own processes and you'll agree that here is a better, sturdier, less costly turbine meter than ever before available. Write to Fischer & Porter Co., 937 County Line Road, Hatboro, Penna.



Unexcelled calibration facilities

The Colburn Memorial Flow Laboratory at Fischer & Porter, the finest and most modern of its kind in the world, provides the basic standards for flow measurement of all F&P flow meters.

FP FISCHER & PORTER CO. Hatboro, Pa.

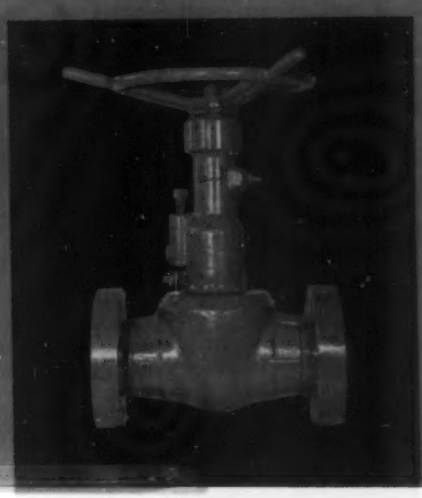
COMPLETE PROCESS INSTRUMENTATION

LA1143

For more data on advertised products, use Readers' Service Cards, last page.

ORBIT VALVES®

IN A POSITION TO SERVE YOU . . .



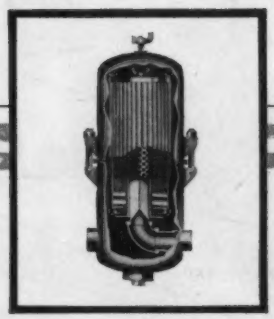
Availability of product and service is one of the many reasons why Orbit valves are preferred by oil men everywhere. Your plant or field operation is never very far from an Orbit Valve man—it's so easy to reach him by phone anytime. Orbit valves are always available through your favorite supply store and well head manufacturers. Also our company maintains warehouse emergency stocks in several strategic locations.

ORBIT VALVE COMPANY

P. O. BOX 699 • TULSA, OKLAHOMA

CLIP THIS AD FOR FUTURE REFERENCE

KEEP IT CLEAN... by Phil Tration



Here's a sales idea for you barbers. What customer could resist the appeal of a shampoo that's so clean even the rinse water is filtered by a Dollinger Staynew Filter? (What ridiculous application will they think of next).

This is just our way of showing you that the uses for Dollinger Filters are truly unlimited. Any liquid, gas or air can be efficiently and economically handled by them. Whether you want to protect machines or processes from damage caused by dust, dirt, oil, grease, or other foreign matter, there is a Dollinger Staynew Filter which will do the job efficiently and economically.

They are in use throughout the world... the recognized standard of quality wherever filters are used.

STAYNEW MODEL ELS LIQUID FILTER

The world-wide use of Dollinger filters on hundreds of liquids is proof of their adaptability to practically any requirement. All known filtering materials are available for any problem regardless of temperature, pressure, or efficiency desired. And, all Model ELS Liquid Filter bodies are available in steel, stainless, monel, herculoy and other non-corrosive metals. Construction can be according to ASME Code specifications.

Send for 12-page Bulletin 300. It contains illustrated data and recommended uses of Dollinger Liquid Filters. Dollinger Corporation, 47 Centre Park, Rochester 3, N. Y.

PROTECTOMOTOR

STAYNEW **DOLLINGER**

FILTERS

LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

For more data on advertised products, use Readers' Service Cards, last page.

CLIP THIS AD FOR FUTURE REFERENCE

The Texas Company Awards Contract to Fluor Corporation
The Texas Company has awarded a contract to The Fluor Corporation, Ltd. for the engineering, procurement and construction of an 80,000 barrel-per-day vacuum pipe still at Port Arthur, Texas.
This new installation will replace existing units, resulting in a net increase of 20,000 barrels per day in the crude capacity of Texaco's Port Arthur refinery.
Engineering work will be performed at Fluor's Los Angeles headquarters. Construction is scheduled to begin in February, 1957 with completion planned in December, 1957.

How to increase the efficiency of your refinery facilities

When your plans for expansion call for single units or complete refineries, be sure to include the experienced leadership of The Fluor Corporation, Ltd. Specializing in efficiency of design which permits low cost future expansion, Fluor is repeatedly asked to bid on new units by a long list of satisfied petroleum clients.

YOU GET THE ADVANTAGES OF A SINGLE, CENTRALIZED RESPONSIBILITY . . . The key to Fluor's success is the ability to think in terms of the entire project. This complete integration has built an outstanding reputation for on-time completion . . . for keeping costs in line with estimates . . . for dependability of throughput and product quality . . . and for plants with low maintenance costs.

Why not get acquainted with Fluor's experience in the petroleum field? Please write The Fluor Corporation, Ltd., 2500 South Atlantic Boulevard, Los Angeles 22, California. Simply indicate your specific interests. A special file of photographs and process information will be mailed immediately.

FLUOR *ENGINEERS and CONSTRUCTORS for the Petroleum, Chemical & Power Industries*

The FLUOR CORPORATION, Ltd., Los Angeles – Mid-Continent Division, Houston – Research Division, Whittier, California – Fluor of Canada, Ltd., Toronto – Singmaster & Breyer, Inc., New York City

For more data on advertised products, use Readers' Service Cards, last page.

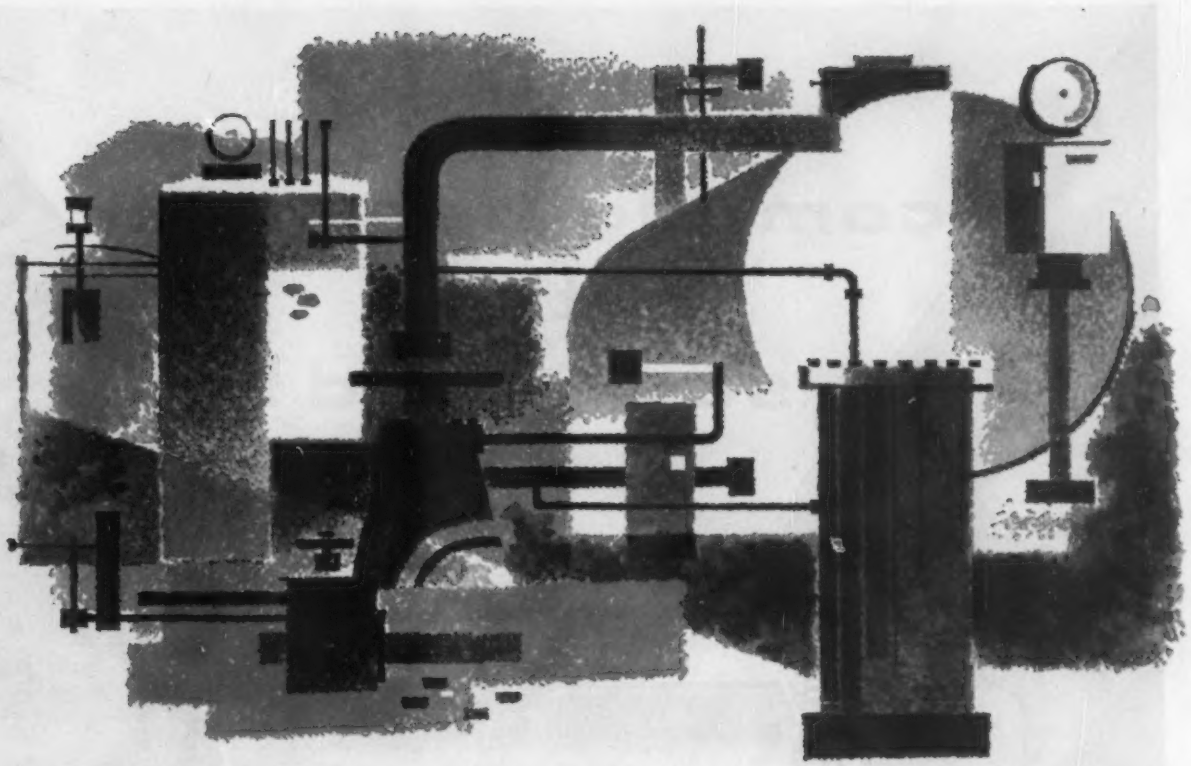
Here's the Nation's NO. 1 Nitrogen Gas Generator

Only Gas Atmosphere's new Nitrogen Generator has all the features you have asked for in a production generator. It comes as a COMPLETE PACKAGED UNIT ready to be set on stream with a minimum of make ready. EXCLUSIVE AUTOMATIC TURN-DOWN enables production coincident with demand, eliminating gas waste. SIMPLIFIED RATIO CONTROL assures uniform gas analysis always. SINGLE BURNER OPERATION means easier combustion control. This new generator develops HIGHEST PURITY NITROGEN and, where required, CO_2 can be obtained from the same unit simultaneously. Here is truly the nation's top nitrogen generator. Be sure you look into it before you buy.

gas Atmospheres, inc

equipment for producing industrial gases

20011 WEST LAKE ROAD CLEVELAND 16, OHIO



How ALCOA Activated Alumina

—controls internal pipeline corrosion
—prevents water contamination of petroleum products
for a major oil company

Operating experience has proved the necessity and advisability of using dehydration on petroleum product pipelines . . . to control internal corrosion and to eliminate, insofar as possible, many problems relating to delivery of products contaminated by water to pipeline terminals. Here's how a major oil company does it:

The drying plant consists of four towers, 20 feet high by 8 feet in diameter, each charged with 18,000 pounds of ALCOA® Activated Alumina. The desiccant is supported by a neutral aggregate bed which rests on a screen supported by a large mesh grating.

Two towers are on stream for 24 hours, and are then regenerated while the other two are put on stream. Each tower dries 25,000 barrels of petroleum products during its 24 hours of service.

Reactivation is accomplished by draining the tower and feeding 150-pound steam into fin type coils which are spaced evenly through the bed of alumina. When the bed is drained, vacuum is pulled on it by a steam jet eductor. Regeneration is complete when the alumina reaches a minimum temperature of 350°F, by which time the vacuum has reached 26 inches or more.

ALCOA Activated Alumina is the "old reliable" desiccant of the oil and gas industry. If you're not already using it, investigate today. Write to ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 717-C Alcoa Building, Pittsburgh 19, Pa.

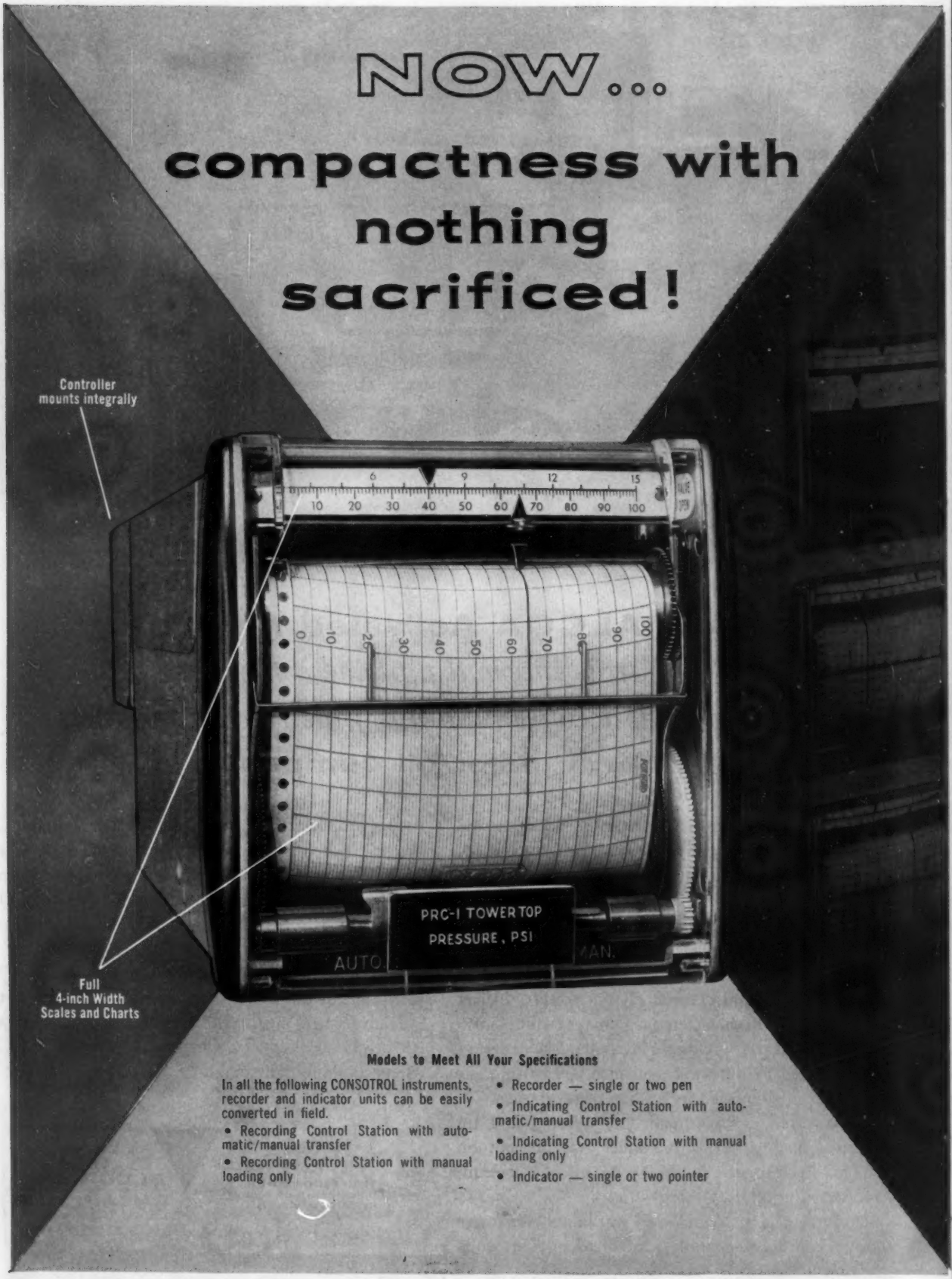
THE ALCOA HOUR
TELEVISION'S FINEST LIVE DRAMA
ALTERNATE SUNDAY EVENINGS

ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

For more data on advertised products, use Readers' Service Cards, last page.

NOW...

compactness with nothing sacrificed!



Models to Meet All Your Specifications

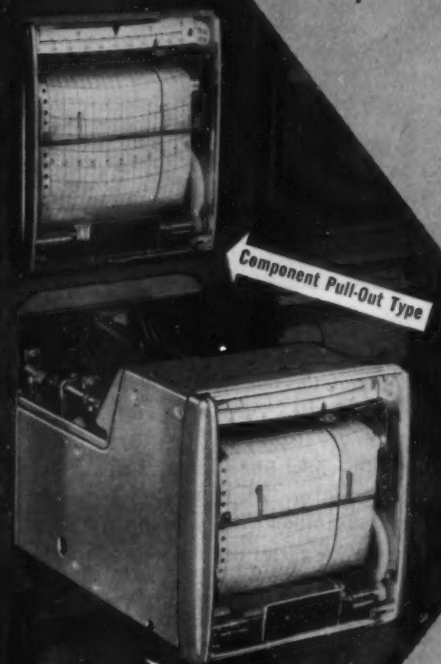
In all the following CONSOTROL instruments, recorder and indicator units can be easily converted in field.

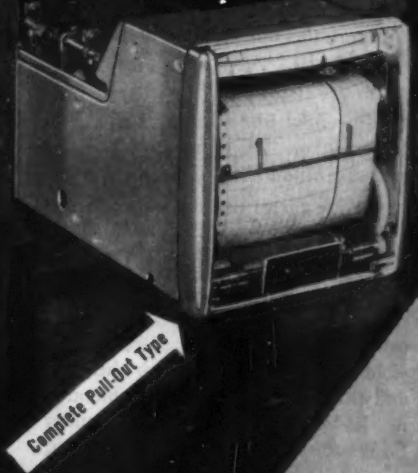
- Recording Control Station with automatic/manual transfer
- Recording Control Station with manual loading only
- Recorder — single or two pen
- Indicating Control Station with automatic/manual transfer
- Indicating Control Station with manual loading only
- Indicator — single or two pointer

For more data on advertised products, use Readers' Service Cards, last page.

CONSOTROL

small-case panel instruments





Here's the "tops" in centralized recording and control efficiency! CONSOTROL* Instruments require the minimum of valuable panel space, yet provide unsurpassed operator convenience, visual accuracy, and ease of maintenance . . . maintain the highest standards of precision and dependability. For example: the simple CONSOTROL method of switching from automatic to manual control requires no memory or extra operations . . . never "bumps" the process. All CONSOTROL charts and scales are full 4-inch width for greatest visibility . . . highest accuracy. When it comes to servicing, there's plenty of "finger room" . . . all parts are uncrowded and easily removable. And just compare inking requirements with other designs. CONSOTROL needs ink filling only once or twice a year! These are only a few of CONSOTROL's advanced design features — available in both fixed-mounting and full pull-out type instruments. Get the complete story. Write for Bulletin 13-18. The Foxboro Company, 743 Neponset Avenue, Foxboro, Mass., U.S.A.

*Reg. U.S. Pat. Off.

FOXBORO

REG. U. S. PAT. OFF.

Consotrol Process Control

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

What it takes to make a 3000 Degree Refractory Concrete

Because of the widespread interest in the use of refractory castables, many furnace operators have asked us for the story behind the performance of B&W's unique refractory concrete, Kaocast.

Here are the answers to some of the most frequently asked questions:

Q. *When you refer to Kaocast as a 3000 degree refractory castable, do you mean that its melting point is 3000° F?*

A. No, this means that its service use limit is 3000° F; its melting point is 200 degrees higher.

Q. *Just what does it take to make a 3000 degree refractory castable like B&W Kaocast?*

A. Let's first define a few terms. Refractory castables are made with granular materials which are volume stable at high temperatures and which can undergo repeated heating and cooling cycles without disintegration. These materials, known as refractory calcines or grogs, are blended with suitable hydraulic binders. The initial strength of a refractory castable is thus developed in the same manner as that of ordinary concrete—that is, through the chemical action between water and the binder. A strong *ceramic bond* is formed when the refractory castable is subjected to temperatures above the vitrification point.

Q. *Then you have a grog, a binder and a method of putting them together. Which is most important?*

A. You can't say that any *one* is most important. It's a combination of all three. Let's take them one at a time. Our grog consists primarily of the proper blend of kaolin and other alumina-silica materials. This ratio enables us to achieve a grog with minimum expansion and shrinkage, a high fusion point, and greater stability under load, at varying temperatures.

Q. *And now, what about the binder?*

A. There are a number of factors responsible for the success of the Kaocast binder. One is the compound Tricalcium Penta-aluminate (3 lime to 5 alumina). This formula produces the most refractory compound (highest melting point) that can be made from lime and alumina. Another is that by using the purest commercially available lime and alumina, the Kaocast binder is substantially free of iron and silica. Such traces of these that are present combine during the pre-firing of the binder to produce stable compounds.

Q. *Just how important is the manufacturing or "blending" of the grog and the binder?*

A. If one factor could be singled out as "most important" it would be quality control.

Direct control over the fineness of materials, prefiring temperatures, and other phases of manufacture is possible at B&W because both the grog and the binder are made and blended at B&W's Augusta Works—under B&W's direct control and supervision.

Q. *These factors you've discussed must add up to some specific advantages of Kaocast. What are they?*

A. B&W Kaocast has all the advantages of easy installation which are responsible for the widespread interest in refractory concretes, plus these exclusive features: It is the only 3000 degree refractory concrete with high resistance to spalling and low volume change throughout its operating range.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga.

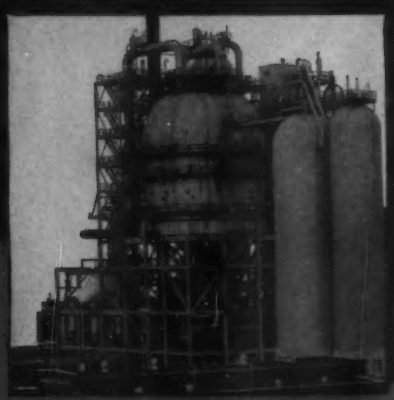
(Advertisement)

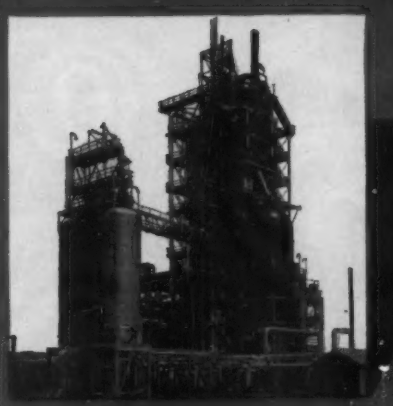
For more data on advertised products, use Readers' Service Cards, last page.

ALL OVER THE WORLD

A. P. GREEN

Serves the Refinery Industry with a Complete Line of High Quality Refractory Products





Throughout the world, the refinery industry relies on A. P. Green high quality refractories for dependable service in thermal and catalytic cracking units, heaters, boilers, stacks, etc.

A world-wide network of A. P. Green distributors is always ready to help you select the right refractories to do the best possible job . . . at the lowest cost. Regardless of location, A. P. Green refractories reach you quickly, safely, exactly as ordered.

A. P. Green
REFRACTORY
PRODUCTS

A. P. GREEN FIRE BRICK COMPANY
Mexico, Missouri, U. S. A.

PLANTS: Mexico, Mo. • Woodbridge, N. J. • Sulphur Springs, Texas
In Canada: A. P. GREEN FIRE BRICK COMPANY, LTD.
Toronto 15, Ontario

BALDWIN-HILL MONO-BLOCK

helps cut down maintenance time on Esso Standard Oil Catalytic Cracker No. 1 at their Bayway Refinery

- The light weight, ease of handling, cutting and shaping speeds application of B-H Mono-Block.
- This one block covers the full range of temperatures up to 1700° F. No need for two insulating blocks for low and high temperatures.
- "Waffle" surface helps application of B-H Super Powerhouse insulating-finishing Cement without use of wire mesh base.
- Felted structure yields to surface projections and irregularities; easily impaled on studs.

BALDWIN-HILL COMPANY

703 Breunig Avenue, Trenton 2, N. J.

Huntington, Ind. Kalamazoo, Mich. Temple, Texas

S See our catalog in Sweet's Plant Engineering File or write for a copy.

B-H Mono-Block in thicknesses from 1" to 4" applied to high temperature lines 14" diameter or over and to high temperature vessels. Finally coated with B-H Super Powerhouse insulating-finishing Cement.

BALDWIN-HILL BH INSULATIONS

COMPLETE LINE OF BALDWIN-HILL INSULATING PRODUCTS

B-H Mono-Block	B-H Super Powerhouse Cement	B-H No. 100 Pipe Insulation
B-H Blanket	B-H No. 1 Insulating Cement	B-H 85% Magnesia Pipe Insulation
B-H Koldboard	B-H No. 52 Asbestos Cement	B-H Calcium Silicate Pipe Insulation
B-H Bond-Tite	B-H Spun Felt Insulation	B-H Mono-Kover Pipe Insulation
B-H Weatherseal	B-H Fine-Fyber Felt Insulation	B-H Spun Mineral Wool Fill

For more data on advertised products, use Readers' Service Cards, last page.

New Steel Grating

with a

BUILT-IN NON-SKID SURFACE

Now Relgrit grating and safety treads bring you the advantage of an open floor—and reduce the threat of expensive skidding accidents, too.

Relgrit's surface is skid-proof because it is coated with a non-absorbent abrasive, ALUNDUM*. This abrasive is permanently bonded with tough, strong Epon Resin, a product of Shell Chemical Corporation. The chemical-resistant surface stays permanently safe under all working conditions—wet or dry . . . muddy or oil-soaked.

*Trademark of the Norton Company, Worcester, Mass.

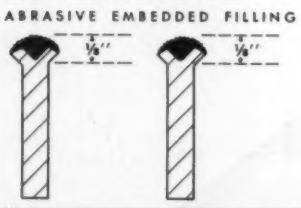
Relgrit®

Patent Applied For

Reliance Steel Products Company · McKeesport, Pennsylvania

For the advantages of an open floor plus permanently *sure footing* the only answer is Relgrit

Relgrit is being used in major industrial plants such as atomic energy installations, chemical plants, oil refineries and many others of every description. After three years of extensive use, these firms found that it's practically impossible to lose footing on Relgrit surfaces. *Even when these surfaces are covered with water, mud, oil or grease!*



Abrasive grains are embedded in a "V" groove at the top of steel bars. Permanent bonding of Relgrit surfaces is assured by new Epon Resin, a product of Shell Chemical Corporation.

For Durability and Safety

Relgrit is extremely tough and durable, having greater wear resistance than steel and 32 times the wear resistance of 1-1.5-3 concrete. Relgrit has an adhesion to metal of 1000 pounds per square inch, a tensile strength of over 3500 pounds per square inch, and a compressive strength of more than 19,000 pounds per square inch. Relgrit is not affected by the most commonly used acids, alkalis or chemicals.

The abrasive surface of Relgrit is actually non-skid . . . not to be confused with the relatively smooth and ineffective serrated surface furnished on other types of grating. In addition Relgrit retains this abrasive skid-resistance permanently.

For additional information, mail coupon below.

RELIANCE STEEL PRODUCTS COMPANY, McKeesport, Pa.
Please send me information on Relgrit Non-Skid Grating and Safety Treads.

Name.....
Firm.....
Address.....
City.....State.....

☐ Literature ☐ Have representative call

RELIANCE STEEL PRODUCTS COMPANY
Relgrit . Grating . Bridge Flooring
McKeesport, Pa.

SAFETY PAYS!

Rockwood Double Strength FOAM puts out flammable liquid fires quicker, at lower cost. Three parts FOAM liquid, 97 parts water and 900 parts of air create a heat-resistant blanket.

Put out fires fast with Rockwood Double Strength FOAM... *and do it inexpensively!*

Rockwood Double Strength FOAM liquid puts out flammable liquid fires quicker at lower cost. Tenacious, fire-smothering bubbles efficiently sweep fire away, and best of all, you pay for only three parts per thousand of the actual extinguishing agent. Three parts of FOAM liquid combine with 97 parts of water and 900 parts of air. The water cost is negligible . . . the air is free . . . obviously the cost of the extinguishing agent must be low.

If you are using other agents in the form of liquids, powders or gases you pay for 100% of the extinguishing agent, against 0.3% for Rockwood Double Strength FOAM . . . and shipping and handling costs are proportionately higher. With Rockwood Double Strength FOAM you buy only the material that binds large volumes of air and water into an efficient fire extinguishing agent. This material is designed to combine with nature's most plentiful materials, air and water, to literally multiply itself hundreds of times.

Rockwood Double Strength FOAM is economical to use . . . not only for actual fire fighting but for training better Fire Fighters.

Send in the coupon below for complete information. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal industrial areas.

ROCKWOOD SPRINKLER COMPANY

Engineers Water . . . to Cut Fire Losses

ROCKWOOD

ROCKWOOD SPRINKLER COMPANY
Portable Fire Protection Division
1610 Harlow Street
Worcester 5, Massachusetts

Please send me your illustrated booklet on Rockwood fire-fighting products.

Name.....

Title.....

Company.....

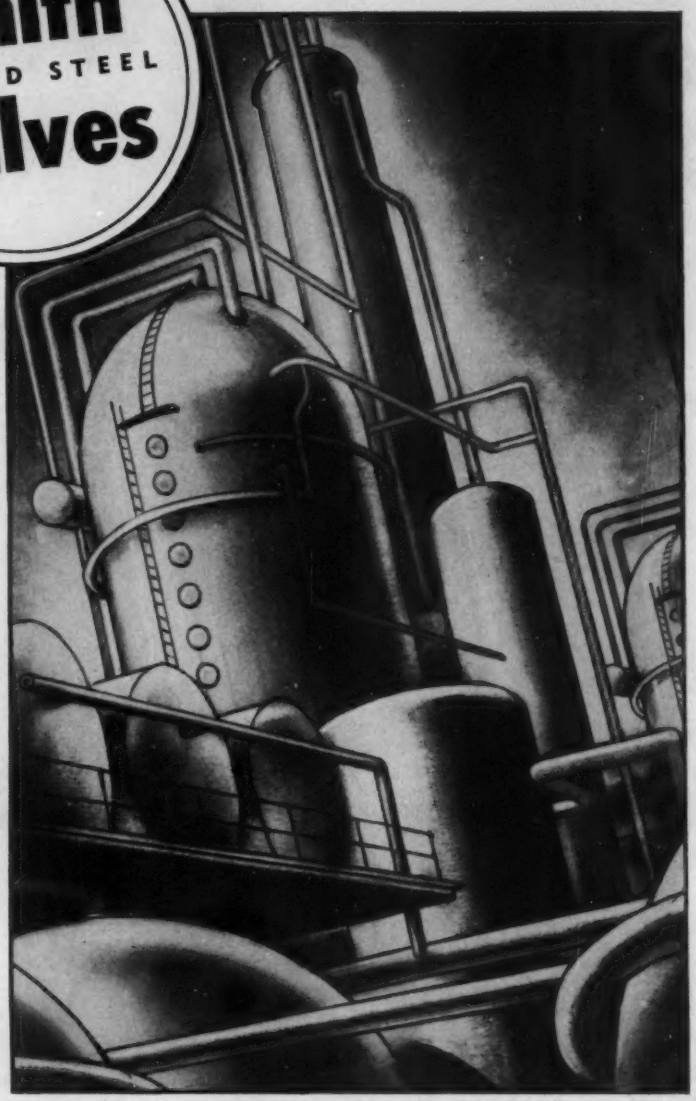
Street.....

City.....*Zone*..*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

Smith FORGED STEEL Valves

150 lb. series
300 lb. "
600 lb. "
½" - 2" incl.

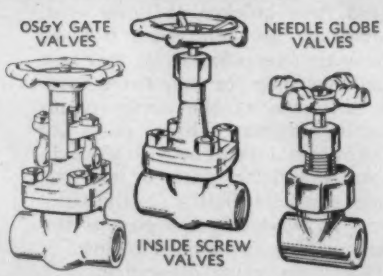


SMITH FLANGED END GATE VALVES

...for longer trouble-free life in service

Smith Flanged End Gate Valves, like all other Smith Valves, are designed, engineered and precision-built to meet the exacting needs of the Process Piping Industries.

A combination of special features designed and built into Smith Valves is your guarantee of longer, trouble-free life in service. They are manufactured according to the most rigid standards of accuracy, high quality of material, expert workmanship, and meet A.S.A. specifications and end to end dimensions. Write today for complete information and prices.



NEW ENGLAND VALVE Corporation

P. O. BOX 1047 • WORCESTER, MASSACHUSETTS

West Coast Distributors: BETHLEHEM SUPPLY CO., LOS ANGELES, CALIFORNIA

SCRUBOSPHERE* ...

... FOR *Cleaner Gas* AT *Less Cost!*

*PEERLESS SPHERICAL
DUST and LIQUID SCRUBBER
FOR GAS PIPELINES

(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are seperated on surfaces of contactor which are kept wet and clean by revolving thru liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3

- The **dust removal ability** of the SCRUBOSPHERE **is superior** because it utilizes wetted surfaces for dust collection which are much more closely spaced than in conventional equipment.
- **Oil loss is minimized** because the oil used to wet the dust collecting surface is lifted mechanically instead of bubbling gas through the oil which results in foaming and loss due to creation of hard-to-separate fine particles.
- **Maximum performance and low cost** — The spherical design means high capacity and performance because it provides maximum dimensions for the contactor and mist extractor which normally are limiting factors in scrubber designs. The vessel cost is reduced because required vessel thickness is only one half that required for cylindrical vessel of same diameter.
- **Versatility** — separates solid and liquid particles with equal efficiency.
- **Low pressure drop** — ½ to ¾ psi at rated capacity depending on nozzle size.

PEERLESS MFG. CO. DALLAS TEXAS

PEERLESS MANUFACTURING CO.

P. O. BOX 13165 DALLAS, TEXAS

Representatives in All Principal Cities

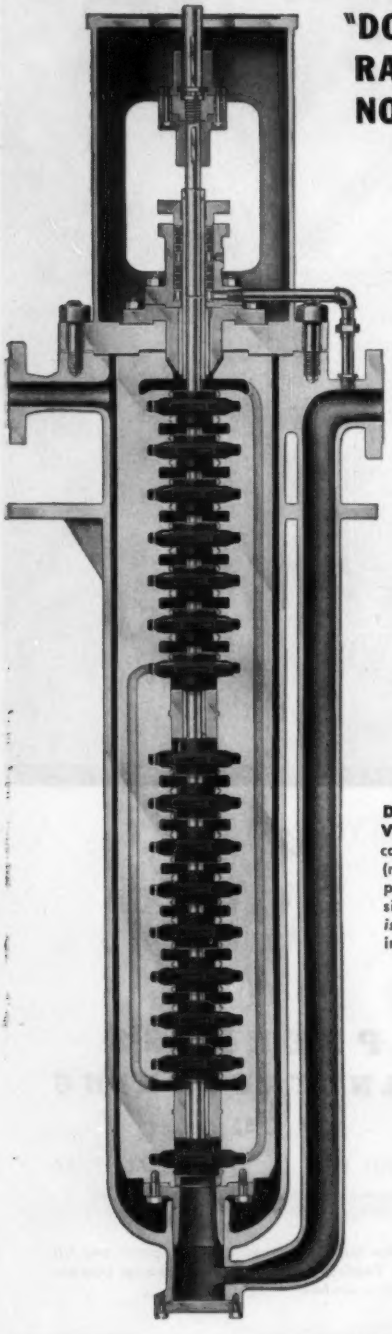
Write for test data showing dust removal and oil loss of Peerless Scrubosphere as against conventional dust scrubber.

For more data on advertised products, use Readers' Service Cards, last page.

Bingham

DOUBLE VOLUTE DOUBLE CASE "HI-PRESS" PUMP

UNSURPASSED HOT OR



"DOUBLE VOLUTE" DESIGN PROVIDES HYDRAULIC RADIAL BALANCE OF ROTATING ELEMENT... NO "SIDE PUSH"...ELIMINATES WEAR AND SEIZURE

The "Double Volute" construction of Bingham Multistage "Hi-Press" Pumps insures perfect radial balance of the rotating element, under all operating conditions . . . completely eliminating wear between rotating and stationary parts. "Double Volute" construction permits maximum use, without exceeding normal clearances, of non-corrosive metallurgy—particularly austenitic steels—normally considered dangerous on account of their galling and seizing characteristics.

This feature also eliminates shaft deflection, permitting **mechanical seals** to establish and maintain a uniform track between contacting faces. This prevents leakage and seal face wear, resulting in **long life for all mechanical seals.**

"Double Volute" design also permits the pumpage to be discharged from the inner into the outer case through *two nozzles* located 180° apart. For hot service, this feature provides adequate circulation of pumpage between the two cases, insuring a uniform temperature rise in all parts – thereby eliminating distortion due to temperature changes.

Location of suction and discharge at top of pump case is particularly suitable for low NPSH conditions.

Bingham "Hi-Press" Pumps have established an exceptional record of long life and trouble-free service wherever they have been installed.

Write your nearest Bingham office for full information.

Diagram of a "Double Volute" double discharge case of a multi-stage pump (right) showing the equal pressure on the opposite sides of impeller. *There is no* "SIDE-PUSH", insuring low maintenance.

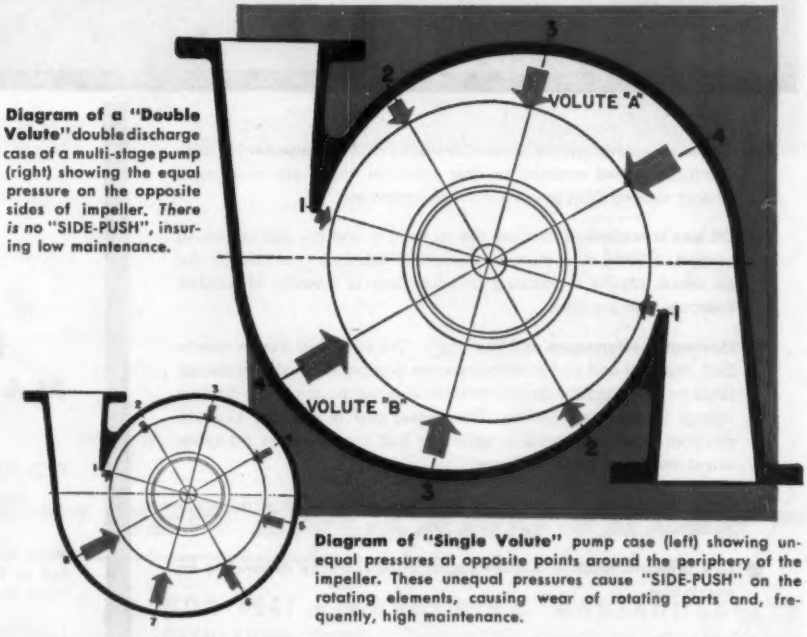
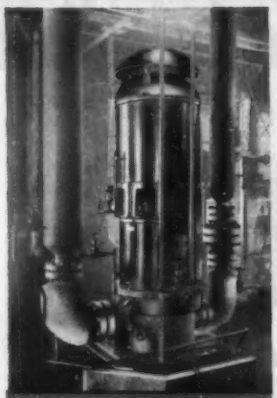
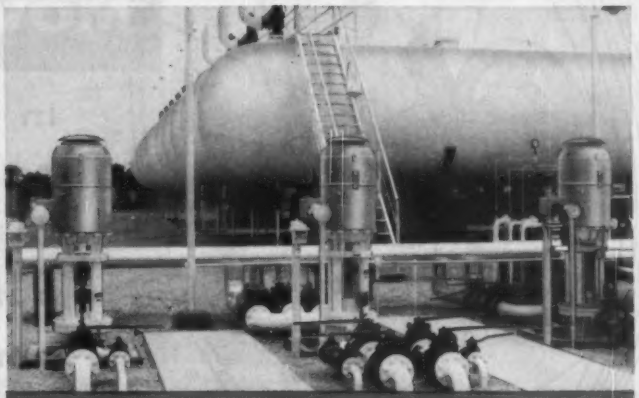


Diagram of "Single Volute" pump case (left) showing unequal pressures at opposite points around the periphery of the impeller. These unequal pressures cause "SIDE-PUSH" on the rotating elements, causing wear of rotating parts and, frequently, high maintenance.

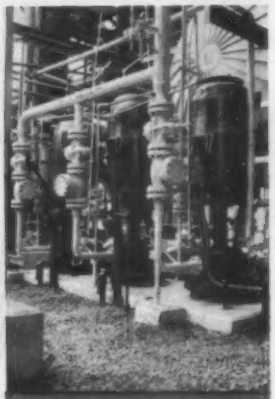
FOR EXTREMELY HIGH PRESSURES
COLD SERVICES



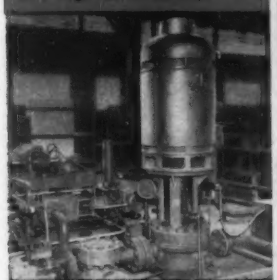
One of a group of Bingham Type HPD Pumps handling 750°F. crude in a large Eastern refinery.



Several Bingham Type HPD Pumps for loading butane under low NPSH conditions at a large Mid-Continent refinery.



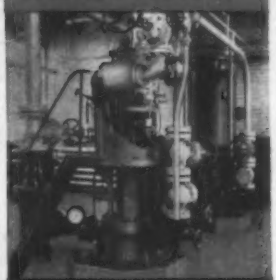
Bingham Type HPD Pumps in polymerization unit charge service at Sun Oil Co., Marcus Hook, Pa.



Bingham "Hi-Press" Pumps for testing pipe to 2500 psi, National Tube Company, Lorain, Ohio.

A group of Bingham "Hi-Press" Loading Pumps at a large cycling plant, Linn, Texas.

Battery of Bingham "Hi-Press" Pumps handling ammoniacal copper solution at 1500 psi, Lion Oil Co., Eldorado, Ark.



One of several Bingham "Hi-Press" Pumps handling 750°F. oil in a large Canadian refinery.

PARTIAL LIST OF REFINERIES AND PETROCHEMICAL PLANTS USING BINGHAM "HI-PRESS" PUMPS

Ashland Oil & Refining Company
British American Oil Company
Canadian Petrofina, Ltd.
Carbide and Carbon Company
Commercial Solvents
Continental Oil Company
Dow Chemical Company
E. I. DuPont de Nemours & Co.
Gulf Oil Company
Imperial Oil Company, Ltd.
Jefferson Chemical Company
Lion Chemical Company
Magnolia Petroleum Company
McColl Frontenac Corp., Ltd.
Phillips Chemical Company
Phillips Petroleum Company
Polymer Corporation
Restigouche Company, Ltd.
Shell Oil Company
Shell Oil of Canada
Socony Mobil
Standard Oil Company of Indiana
Spencer Chemical Company
Sun Oil Company
Texas Oil Company

Bingham SINCE 1921

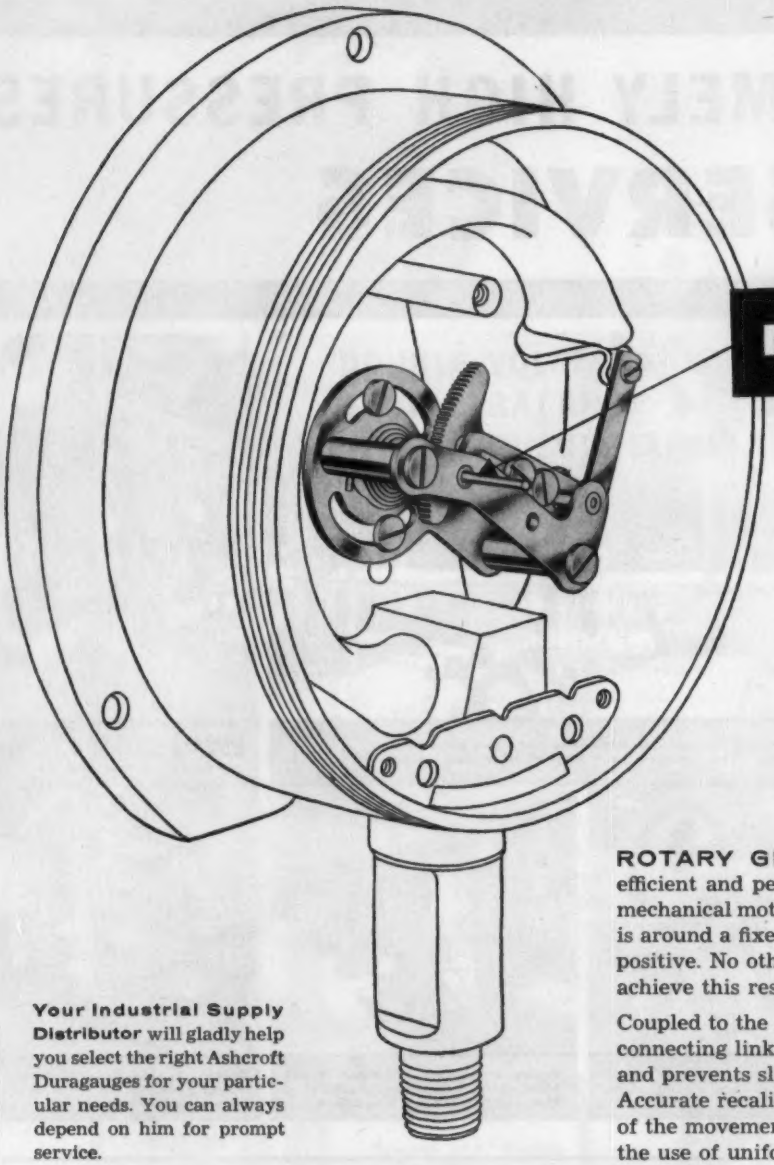
DOUBLE VOLUTE PUMPS RADIAL BALANCE

BINGHAM PUMP COMPANY
General Offices: 2800 N.W. Front Avenue, Portland 10, Oregon
Factories: Portland, Ore. • Vancouver, B. C., Canada

SALES AND SERVICE OFFICES

BOSTON, MASS.
CHICAGO, ILL.
CLEVELAND, OHIO
DALLAS, TEXAS
DENVER, COLO.
HOUSTON, TEXAS
KANSAS CITY, MO.
LOS ANGELES, CALIF.
NEW ORLEANS, LA.
NEW YORK CITY, N.Y.
PHILADELPHIA, PA.
PITTSBURGH, PA.
SAN FRANCISCO, CALIF.
SEATTLE, WASH.
ST. LOUIS, MO.
ST. PAUL, MINN.
TULSA, OKLA.
TORONTO, ONT., CAN.
VANCOUVER, B. C., CAN.

For more data on advertised products, use Readers' Service Cards, last page.



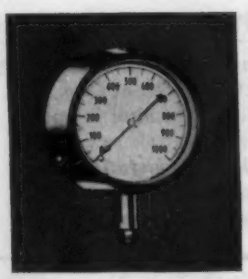
Why does the MOVEMENT in the ASHCROFT DURAGAUGE outperform all other types?

ROTARY GEARED MOTION, the most efficient and perfect method of transmitting mechanical motion ever developed. Because rotation is around a fixed center, pointer position is always positive. No other type of movement can ever achieve this result.

Coupled to the movement is a one-piece connecting link that guarantees correct calibration and prevents slippage or parting under tension. Accurate recalibration is easy from front or rear of the movement. Universal adjustability permits the use of uniformly graduated dials, thereby facilitating maintenance.

The Ashcroft Duragauge is available with all-stainless-steel movement or stainless steel with nylon bearings and pinion gear. There are case designs and materials, Bourdon tube materials, pressure ranges and dial sizes to meet your service conditions exactly. Save time, trouble and money. Specify the pressure gauges of highest sustained accuracy and durability — Ashcroft Duragauges.

Your Industrial Supply Distributor will gladly help you select the right Ashcroft Duragauges for your particular needs. You can always depend on him for prompt service.



1850 ASHCROFT U.S.A.

MAXWELL MANNING & MOORE INC. TRADE MARK

In Canada: *Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario*

ASHCROFT GAUGES

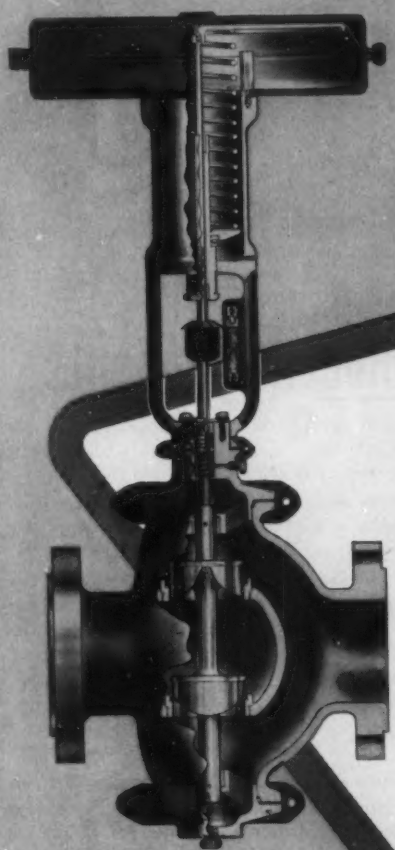
A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

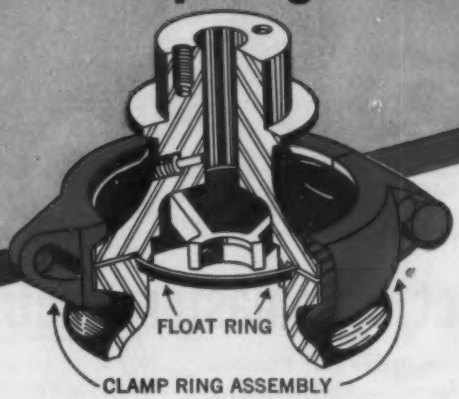
MAKERS OF 'AMERICAN' INDUSTRIAL INSTRUMENTS, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN-MICROSEN' INDUSTRIAL ELECTRONIC INSTRUMENTS, *Stratford, Conn.* 'HANCOCK' VALVES, *Watertown, Mass.* 'CONSOLIDATED' SAFETY RELIEF VALVES, *Tulsa, Oklahoma.* AIRCRAFT CONTROL PRODUCTS, *Danbury & Stratford, Conn. and Inglewood, Calif.* "SHAW-BOX" AND 'LOAD LIFTER' CRANES, 'BUDGIT' AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES, *Muskegon, Mich.*

New Clamp Ring···Float Ring Seal*

On BS&B's *Super* 70 series

Diaphragm Control Valves





...Makes Other Valve Closures Obsolete!

* Patented

The BS&B Super "70" Series Diaphragm Control Valves offer a thoroughly proven concept of pressure sealing, known as the clamp ring — float ring seal, for top and bottom closures.

Tightening of the heavy forged steel clamp ring seals the nickel plated, soft steel float ring into a precision machined, wedge-shaped groove formed by the valve body and the closure plate. Float rings are available in other materials compatible with alloy or stainless steel valve bodies.

Under pressure, the float ring is wedged tighter into its annular groove — thus increasing the sealing force. The higher the internal pressure, the tighter the seal!

This actuation under pressure also creates automatic compensation for thermal expansion under fluctuating temperatures. The seal is maintained under vacuum because initial tightening of clamp ring provides sufficient sealing force to hold a vacuum differential of up to 15 psi. Valves may be disassembled as often as required without damage to the clamp ring — float ring seal.

While a new BS&B exclusive feature in the diaphragm valve field, the float ring seal concept has also been most successfully used over the past several years by other leading manufacturers of high pressure equipment.

Why Clamp Rings Are Used On Super "70" Series Valves

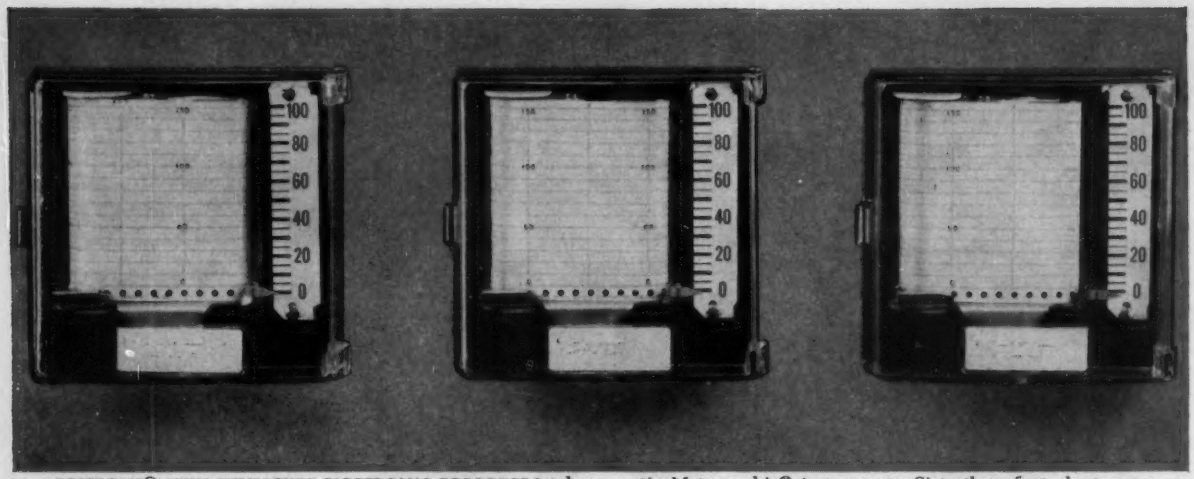
The equivalent bolting area of the clamp rings used on Super "70" Series Valves is greater than that of a similarly rated ASA flange — yet is lighter in weight and more trim in appearance. Clamp rings make the valve easier to disassemble for servicing and cleaning because only two bolts must be removed, and permit the valve yoke to be oriented to any convenient position.

For more information on the all-new BS&B Super "70" Series Diaphragm Control Valves, ask your BS&B Sales Engineer — or write for Catalog 70-11.

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-F3
7500 East 12th Street Kansas City 26, Missouri



BRISTOL'S® NEW MINIATURE ELECTRONIC RECORDERS take only 5" x 5⅛" panel space—can be mounted on 6½" centers. Size and external appearance completely match Bristol's pneumatic Metagraphic® instruments. Sixty-three-foot chart provides 31-day record at 1" per hour. Wide variety of chart speeds available with easily changed gears.

New! Compact Dynamaster electronic instruments

Full plug-in versatility, true servo-driven null-balance operation, high sensitivity are features of Bristol's new Series 663 Dynamaster recorders, indicators.

Now, for the first time, you can get all the inherent accuracy, stability and versatility of Bristol's electronic potentiometer and bridge instruments in a line of instruments designed for graphic panels and centralized recording and indicating of large numbers of variables.

The new Bristol 663 Series Dynamaster Recorders feature the same basic mechanism as full-sized Dynamaster instruments, completely redesigned and repackaged to carry out the basic graphic panel idea. They provide compact, centralized electronic recording, indication, and control of temperature, pressure, vacuum, pH, humidity, liquid level, speed, mechanical motion, smoke density, voltage, current, power, resistance, strain or any other variable that can be translated into an electrical quantity. Check these design features:

1. True motor-driven null-balance operation. Bridge, potentiometer or differential transformer types available. No delicate galvanometer movement, no moving coil, no pivots employed. Unaffected by severe vibration. Plenty of torque for operating control mechanism, retransmitting slidewires, alarm contacts, etc. with full accuracy.

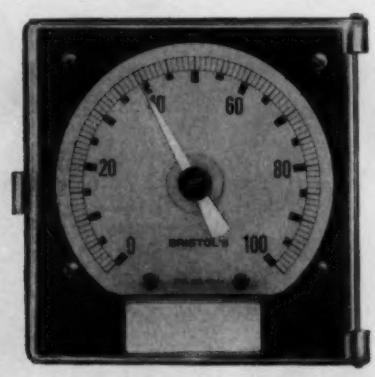
2. Reads directly from sensing elements such as thermocouples, resistance bulbs and other d-c output elements. No external converters with vacuum tubes and adjustments.

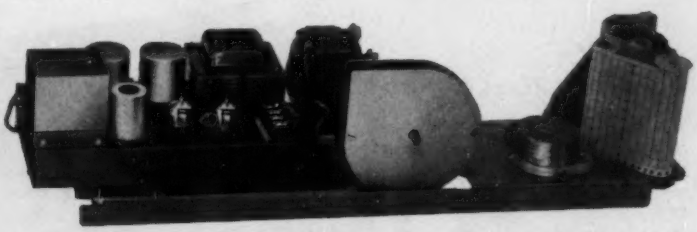
3. Full plug-in design. Change from an indicator to recorder with the same type of measuring circuit and terminal arrangement, or vice versa, in seconds. Or withdraw the chassis part-way for chart change or inking without disturbing operation in any way.

4. Easy range change in field. Just substitute desired range card; no soldering required. Wide variety of ranges and spans available.

5. Requires small panel space of only 5 x 5⅛ inches. Fifteen recorders or indicators mount in space required for two standard size electronic recording instruments.

Write today for complete data on the outstanding new Bristol Series 663 Dynamaster Instruments for your applications. The Bristol Company, 111 Bristol Road, Waterbury 20, Connecticut. 6.52





INDICATING RECEIVER (*left*) is interchangeable—in seconds—with recorder. Both indicators and recorders may be drawn to intermediate position for chart change, pen inking or inspection. Plug-in chassis (*above*) of resistance thermometer recorder. No external converter involving vacuum tubes and adjustments is required to operate Bristol's miniature Dynamaster instruments from resistance bulb thermometer or thermocouple.

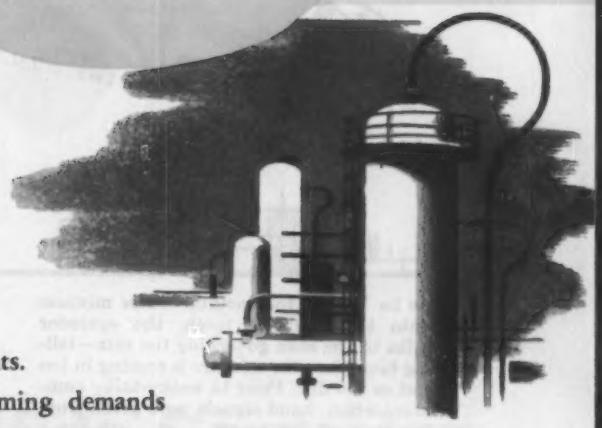
BRISTOL *TRAIL-BLAZERS IN PROCESS AUTOMATION*

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Accuracy...

is TRADITIONAL at WESTERN

Accuracy
IS VITAL TO
CATALYTIC
REFORMING



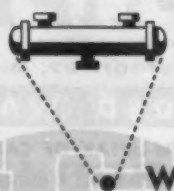
Many of our customers employ a catalytic reforming process in the production of premium motor fuels, high yields of aromatic hydrocarbons, or high-quality aviation gasoline components.

Whatever its application, catalytic reforming demands *unerring accuracy* in the heat transfer equipment employed—accuracy in rating—in design—in welding—in complete fabrication.

Western Heat Exchangers meet these demands because Western's rating and design engineering—manufacturing techniques—close attention to detail—are dedicated to *accuracy first.*

Western has successfully participated in the development of many catalytic reforming units now in service throughout the world.

Western's representatives stand ready to serve you . .



WESTERN

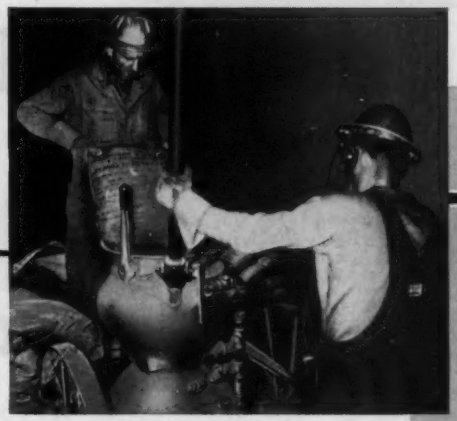
HEAT EXCHANGERS

WESTERN SUPPLY COMPANY

P.O. Box 1388 – Tulsa, Oklahoma

ELECTRONICS and *Mud*

Notice the ear phones on his head. He is in constant voice communication with the gunnite operator—receives instructions so that exactly the right proportions of water and dry castable are used. Result: longer refractory life in refinery vessel installations.



As he "guns" the castable-water mixture onto the retaining mesh, the operator talks to the man governing the mix—telling him when the mixture is coming in too wet or too dry. Prior to walky-talky communication, hand signals were given from hundreds of feet away.

Off-stream time hinges upon the durability of the equipment in the refinery. That's why Bigelow-Liptak has concentrated so much upon improvement of castable application to refinery vessels. As a result, you'll find B-L installations are hanging up record after record for long life and consequently helping to reduce the per-barrel cost of refined products. Remember that Bigelow supplies a complete one-source service to refineries: engineering, materials and erection. Better investigate today!

BIGELOW-LIPTAK *Corporation*

AND BIGELOW-LIPTAK EXPORT CORPORATION

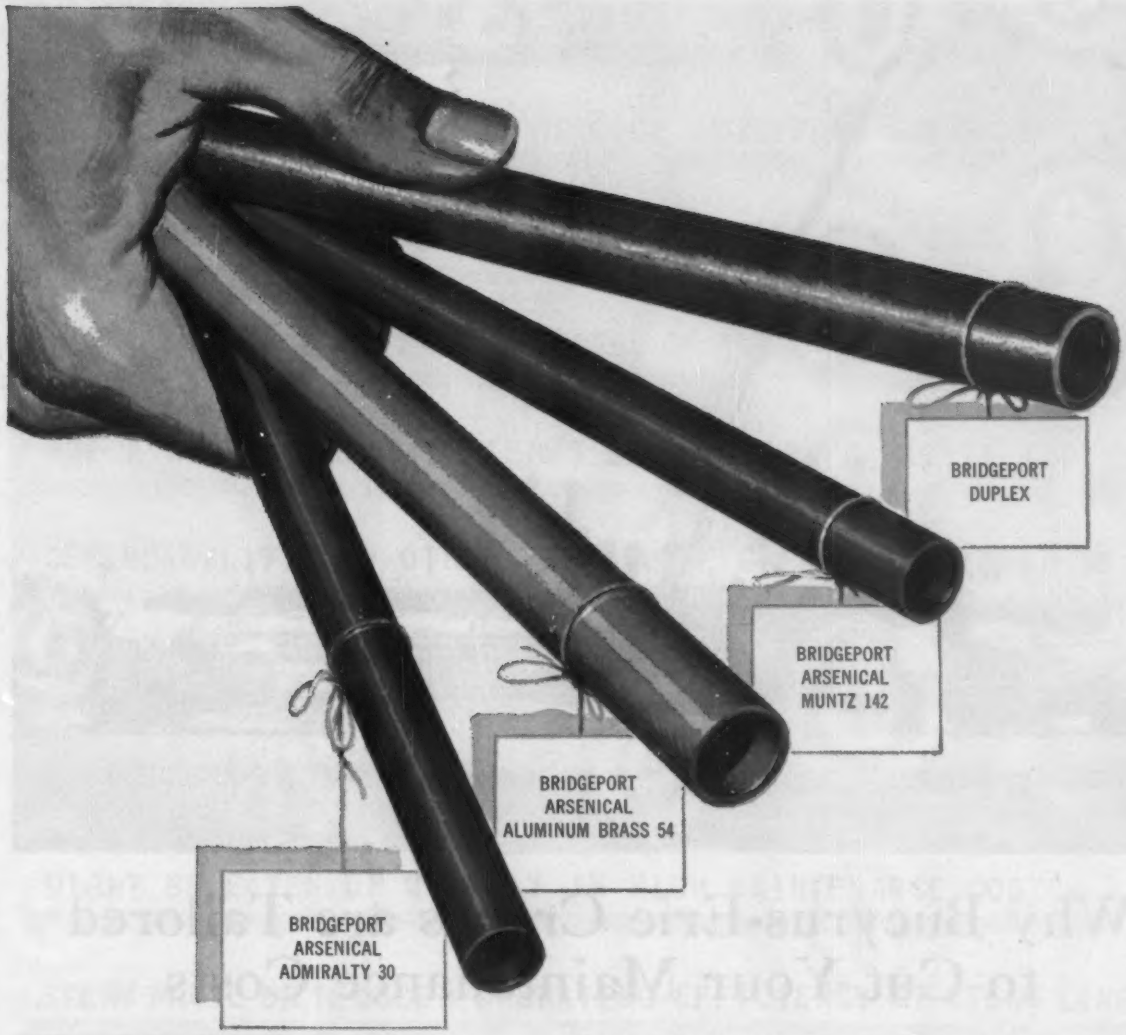
13300 PURITAN AVENUE, DETROIT 27, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., *Toronto, Ontario*

ATLANTA • BOSTON • BUFFALO • CHICAGO • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MIAMI • MINNEAPOLIS • NEW YORK • PHILADELPHIA • PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • TULSA • MONTREAL • SAULT STE. MARIE, ONT. • VANCOUVER • WINNIPEG

For more data on advertised products, use Readers' Service Cards, last page.



4 Ways to Lick Sulfide Corrosion In Your Heat Exchangers

Take your choice! You'll find all four of the tubes illustrated ideal for process condensers and exchangers handling heavy concentrations of hydrogen sulfides.

Arsenical Admiralty has established excellent performance records in refineries and processing plants handling low sulfur petroleum products and where fresh or saline cooling water of low to moderate velocity is used.

Arsenical Aluminum Brass is generally used where sea water is the coolant and where water velocities are high.

Arsenical Muntz, while having the same corrosion resistance to salt or fresh water as Admiralty, is resistant to the action of sulfides.

Duplex Tubes offer the advantage of a combination of metals to meet different corrosive attacks on both the product side and on the cooling water side. For instance, on high-stage gas condensers handling wet gas high in hydrogen sulfide and containing ammonia, low-carbon steel/Admiralty Duplex Tubes have given unusually long service in most installations.

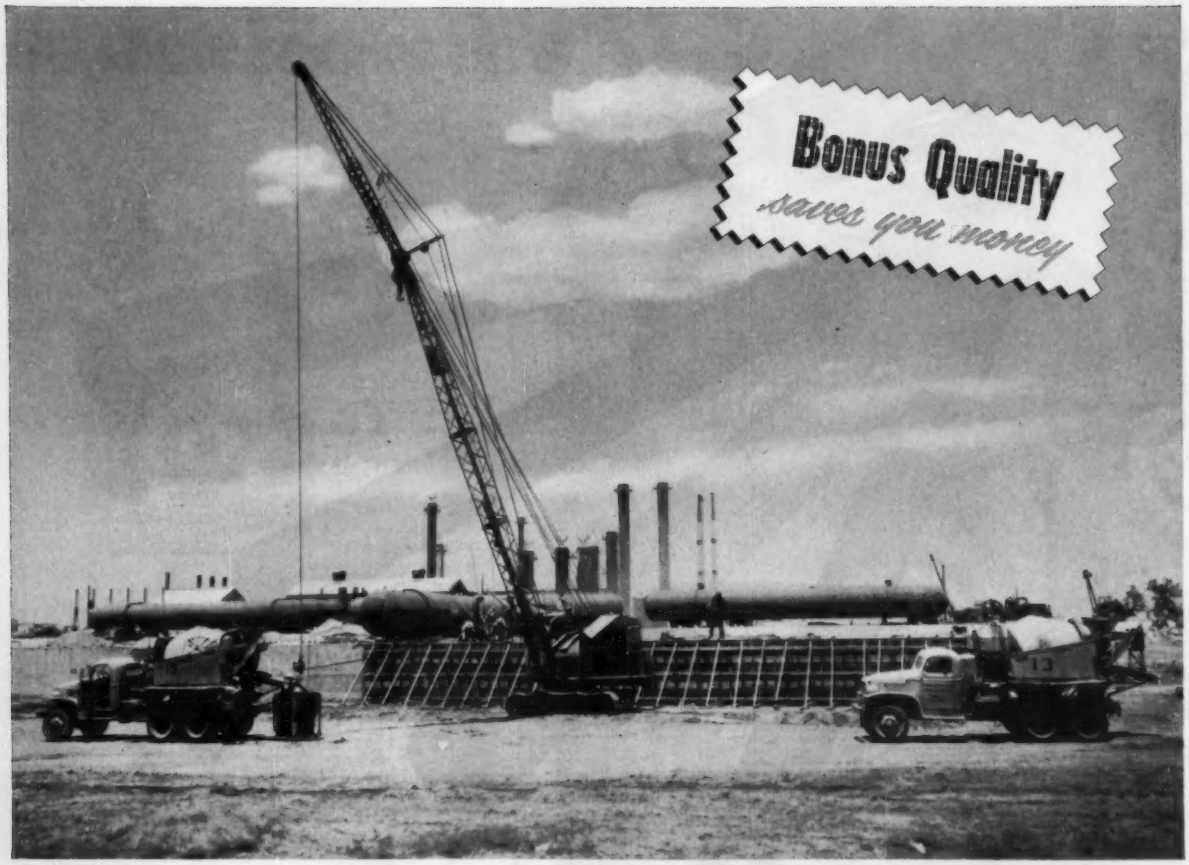
Whatever your choice, whatever your tube problem, it will pay you to get in touch with Bridgeport. Our long years of experience in the manufacture and application of condenser and exchanger tubing will save you time, money and trouble. Call your nearest Bridgeport Office today.

For full details, send for copies of Condenser Tube Handbook and Duplex Tube Manual.

Bridgeport BRASS CO. **BRIDGEPORT BRASS**

Bridgeport Brass Company, Bridgeport 2, Conn. • Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

For more data on advertised products, use Readers' Service Cards, last page.



Why Bucyrus-Erie Cranes are Tailored to Cut Your Maintenance Costs

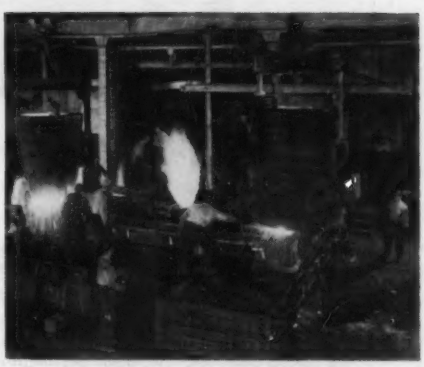
Strength to handle loads smoothly and easily . . . ability to inch those loads accurately into place . . . extra large area clutches and brakes that take hold uniformly with a smooth firm grip — these are some of the features of Bucyrus-Erie 22-B and 38-B cranes that enable them to handle refinery maintenance at lowest possible cost.

Their box-section booms are fabricated by the most modern welding processes with light steel chord angles strongly laced to stand up under the compression and swinging stresses applied in fast crane operation. An independent boom hoist enables the operator to change boom angle at any point in the cycle . . . permits accurate positioning of loads. The big clutches and brakes are instantly responsive, smooth in action, provide utmost load-handling ability. Special disc-type boosters on the 38-B drum clutches give the operator minute control.

Add to these the optional features of variable multiple-part boom suspension (pendant-type for 22-B; mast and pendant-type for 38-B) for obtaining slower boom hoisting and lowering and greater accuracy of control, independent propel and third drum equipment for the 38-B, and you'll see why it will pay to have your plant Bucyrus-Erie equipped. Crane capacities (75% rating): 23,700 lbs. for the 22-B with 35-ft. boom at 12-ft. radius (27,000 lbs. for Heavy Duty 22-B); 49,000 lbs. for the 38-B with 45-ft. boom at 15-ft. radius. Larger capacity crawler cranes and 15- and 25-ton Transit Cranes also available. 314E56

BUCYRUS ERIE

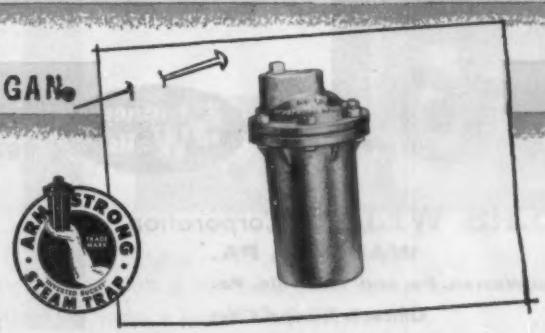
South Milwaukee, Wisconsin



Bonus Quality Castings used in Bucyrus-Erie machines are produced in the company's own foundries where careful laboratory supervision holds them to the highest standards. Workmen are shown here pouring steel castings at the South Milwaukee Plant.

For more data on advertised products, use Readers' Service Cards, last page.

IT PAYS TO LOOK BEHIND THE PRICE TAG WHEN YOU SPECIFY OR BUY STEAM TRAPS. THE PRICE OF ARMSTRONG STEAM TRAPS REFLECTS MASS-PRODUCTION ECONOMIES RESULTING FROM THE LARGEST VOLUME OF TRAP BUSINESS OF ANY MANUFACTURER. THEY ARE A REAL BARGAIN IN TERMS OF QUALITY, CAPACITY AND DEPENDABILITY. NO OTHER TRAPS HAVE EVER ESTABLISHED SO ENVIABLE A RECORD FOR LONG SERVICE WITH LOW MAINTENANCE EXPENSE. APPARENT SAVINGS IN PURCHASE OF "CHEAP" TRAPS MIGHT BE EATEN UP QUICKLY IN HIGH MAINTENANCE COSTS, STEAM WASTE OR REDUCED OPERATING EFFICIENCY OF STEAM LINES OR EQUIPMENT. MANY PLANTS THAT HAVE KEPT ACCURATE RECORDS HAVE STANDARDIZED 100 PERCENT ON ARMSTRONGS. WRITE FOR CATALOG J. ARMSTRONG MACHINE WORKS, 8522 MAPLE STREET, THREE RIVERS, MICHIGAN.



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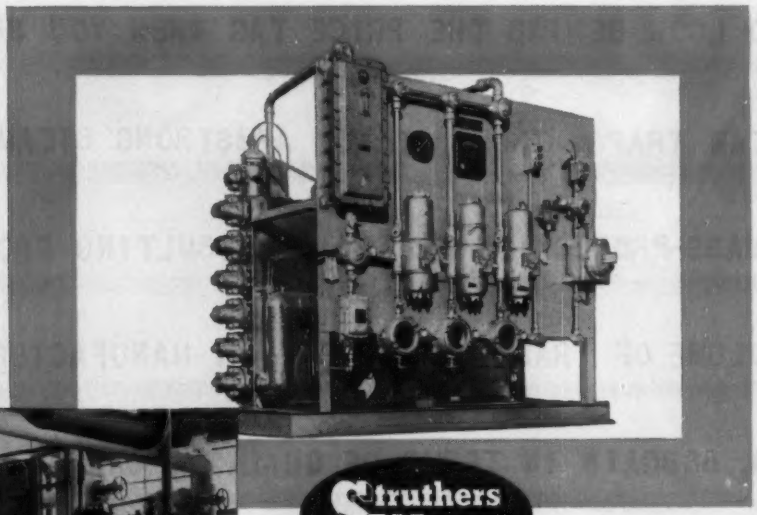
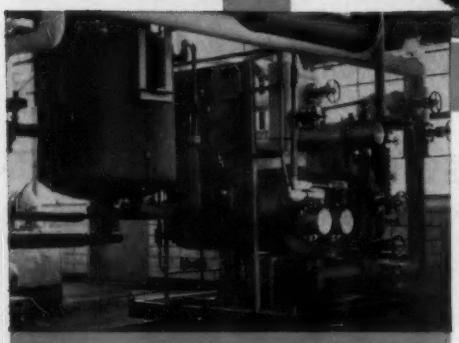
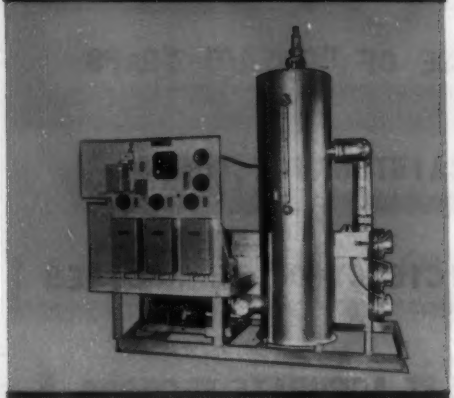
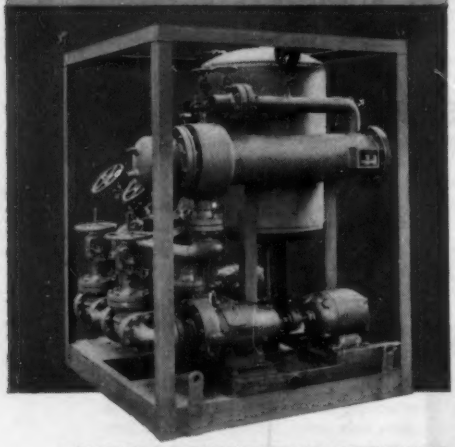








Struthers Wells

High Temperature Heating

by Circulating Medium

Struthers Wells supplies circulating heating equipment for a wide range of temperatures and sizes. Many smaller units can be supplied as a "package," completely assembled and ready for operation.

The units illustrated show three electrically heated units for Dowtherm and other fluids, for capacity to above 1,000,000 BTU per hour. Also shown is a circulating cooling unit, (lower left side illustration).

Struthers Wells can supply standard units for capacities from 100,000 BTU per hour to about 40,000,000 BTU per hour. Temperatures range from about 350°F to above 1500°F.

Fired heaters for a wide range of services, including steam superheating, oil and gas heating are also a Struthers Wells specialty. Hundreds of units are in successful service.

If you require heat above the temperature range of available steam pressures, Struthers Wells engineering experience and facilities are always available.

Struthers Wells

STRUTHERS WELLS *Corporation*

WARREN, PA.

Plants at Warren, Pa. and Titusville, Pa.

Offices in Principal Cities

Struthers Wells Products

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

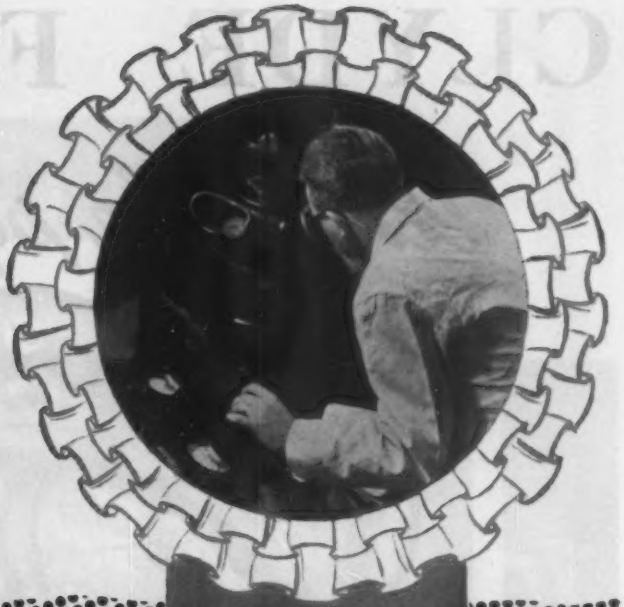
Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

MACHINERY DIVISION

MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

For more data on advertised products, use Readers' Service Cards, last page.

ON STRIVING FOR PERFECTION



50 YEARS OF RESEARCH AND ACHIEVEMENT IN INSULATION

From long experience in industrial insulation Newalls have developed modern techniques to meet the special needs of Oil Refinery and Petro-Chemical plants erected abroad.

In step with field activities, Newalls Research Laboratories have striven constantly for higher standards in insulation practice.

Newalls ranges of insulants for SINGLE or DOUBLE LAYER application meet temperatures from −300°F up to over 2,000°F. They include Newalls (Reg'd Brand) 85% Magnesia, Nicosil, Newtempheit, and Amosite Asbestos, which are carefully controlled at every point of manufacture and are designed to maintain their initial standard of service throughout the life of the plant.

LEADERS IN REFINERY INSULATION ▶

Newalls

NEWALLS INSULATION CO. LTD., *Head Office:* WASHINGTON, CO. DURHAM, ENGLAND

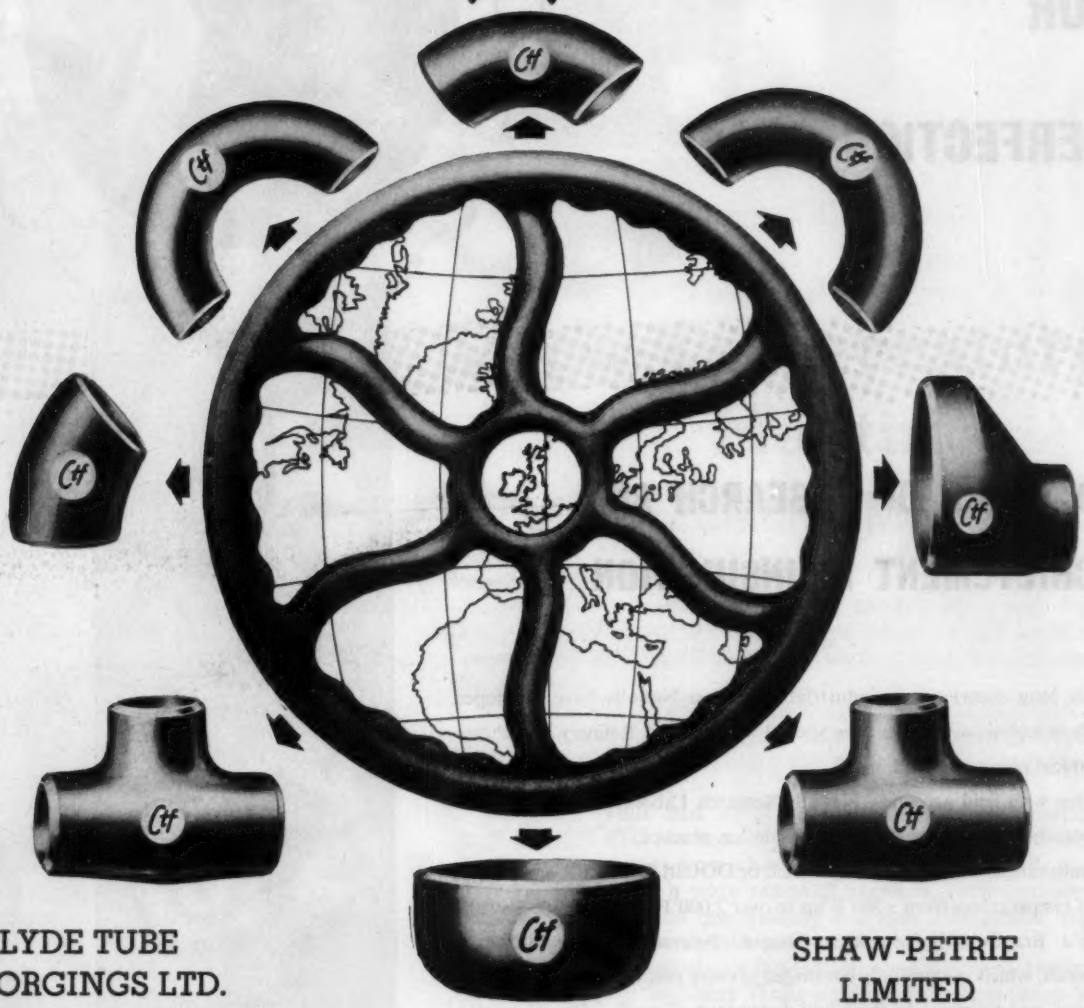
A member of the TURNER & NEWALL ORGANISATION

Agents and vendors in most markets abroad.

For more data on advertised products, use Readers' Service Cards, last page.

CLYDE FITTINGS

link the pipe world



CLYDE TUBE FORGINGS LTD. make all types of seamless steel and alloy butt welding fittings

SHAW-PETRIE LIMITED fabricate and erect pipework for every project

SHAW-PETRIE LIMITED | **CLYDE TUBE FORGINGS LTD**

NORTH HILLINGTON · GLASGOW SW2 · TELEPHONE HALFWAY 5551-6

LONDON OFFICE 157 VICTORIA ST. SW1
TELEPHONE TATE GALLERY 9325-6
AND AT SOUTH SHIELDS, LIVERPOOL AND BELFAST

OVERSEAS

CANADIAN CLYDE TUBE FORGINGS P.O. BOX 278 WESTON ONTARIO

New Zealand · *Barbados* · *Mexico and*
East West · *British Guiana* · *Venezuela*
Central and · *Jamaica* · *Belgium Holland*
South Africa · *Trinidad* · *Norway Sweden*
Australia · *Italy Spain* · *and Finland*

CLYDE TUBE FORGINGS OF AMERICA PORTLAND OREGON U.S.A.

For more data on advertised products, use Readers' Service Cards, last page.

Refinery Insulation

All CAPOSITE moulded insulation materials are made of Amosite asbestos. The photograph clearly demonstrates the immense volume which is obtained when the natural Amosite is fiberised—the sign of high efficiency as an insulating medium.

CAPOSITE is supremely well suited to the thermal insulation of oil refineries. With a limiting temperature of 1000°F., high thermal efficiency and great structural strength and resilience, CAPOSITE has gained for itself a unique position among thermal insulation materials used by the Oil Industry.

CAPOSITE MOULDED ASBESTOS FIBRE PIPE INSULATION

EFFICIENCY DATA SHEET—PIPE SIZES 6" to 10" BORE.

HOT FACE TEMPERATURE °F.			400°F			600°F			800°F		
THERMAL CONDUCTIVITY K=B.Th.U. in./sq. ft./hr./in./°F.			0.43			0.47			0.53		
MEAN TEMPERATURE °F.			250			350			450		
Nominal Pipe Size	O.D. pipe	Thickness of Insulation	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.	Heat Loss B.Th.U. sq. ft. hr.	Effic. %	Surface Temp. °F.
6"	6¼"	1"	135	87·7	126	233	90·6	167	354	92·5	218
		1½"	102	90·8	107	177	92·9	135	270	94·3	171
		2"	83·6	92·4	97	145	94·1	118	223	95·3	145
		2½"	71·8	93·5	91	125	95·0	107	192	96·0	128
		3"	63·5	94·2	86	110	95·5	100	170	96·4	117
		3½"	57·3	94·8	83	100	96·0	95	154	96·7	109
		4"	52·6	95·2	81	91·7	96·3	91	142	97·0	103
8"	8¼"	1"	130	88·0	127	225	90·8	169	341	92·7	222
		1½"	97·7	91·0	108	169	93·1	137	258	94·5	174
		2"	79·2	92·7	98	138	94·4	120	211	95·5	148
		2½"	67·4	93·8	92	117	95·2	109	180	96·1	131
		3"	59·2	94·6	87	103	95·8	102	159	96·6	120
		3½"	53·2	95·1	84	92·7	96·2	96	143	96·9	111
		4"	48·5	95·6	82	84·6	96·5	92	131	97·2	105

These figures are compiled from results of official tests by THE NATIONAL PHYSICAL LABORATORY, TEDDINGTON, computed in accordance with formulae shown in BRITISH STANDARD SPECIFICATION appendices.

Please write for full technical details

THE CAPE ASBESTOS COMPANY LIMITED
114 & 116 Park Street, London, W.1.
Cables: Incorrupt, London.

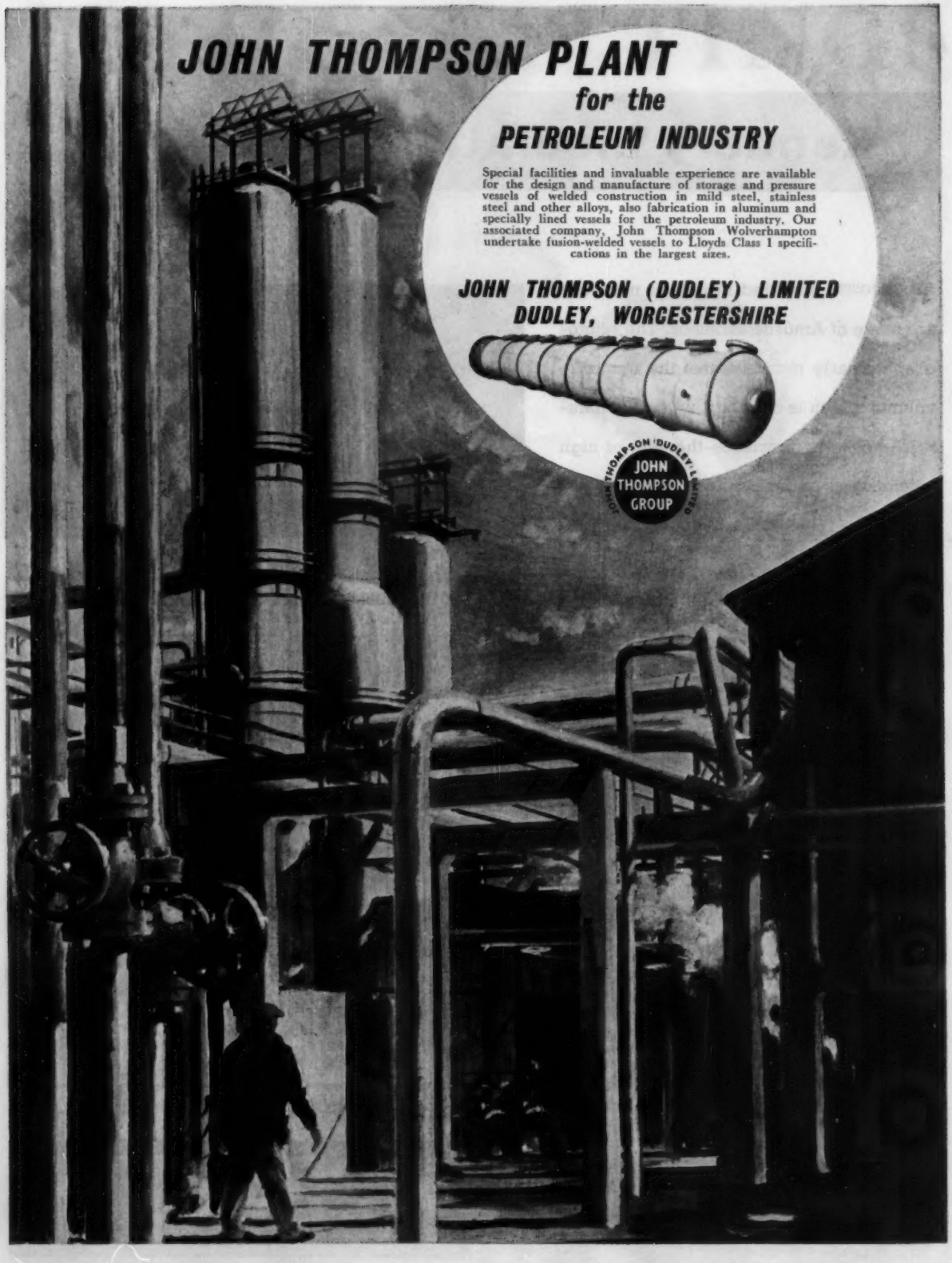
CAPOSITE REGD
Amosite Asbestos Blocks and Pipe Sections

Enquiries in CANADA to: Cape Asbestos (Canada) Ltd., 200 Bloor Street East, Toronto, Ont.
U.S.A.: The North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

SOUTH AFRICA: Cape Asbestos South Africa (Pty.) Ltd., P. O. Box 2533, Johannesburg; ITALY: Capamianto S.P.A., via Sant' Antonino 57, Turin. FRANCE: Isolamiante S.A. 37 Avenue Franklin D. Roosevelt, Paris 8e.

CAPE

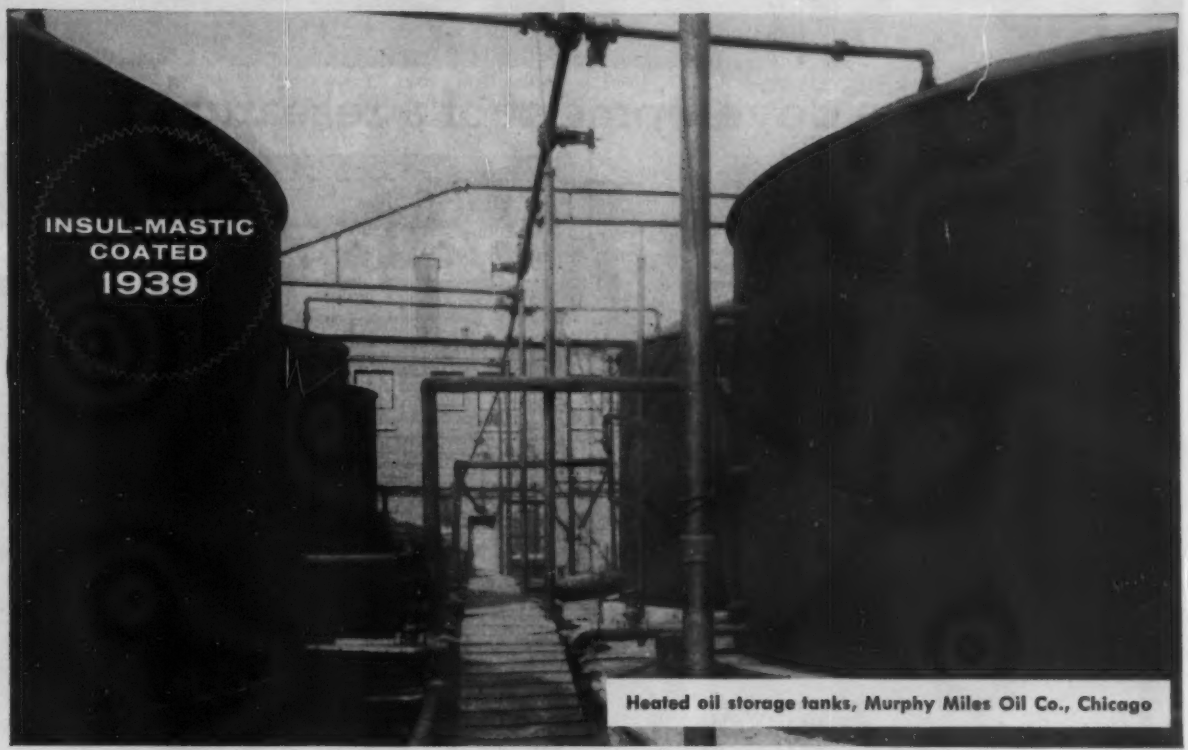
For more data on advertised products, use Readers' Service Cards, last page.


JOHN THOMPSON PLANT
for the
PETROLEUM INDUSTRY
Special facilities and invaluable experience are available for the design and manufacture of storage and pressure vessels of welded construction in mild steel, stainless steel and other alloys, also fabrication in aluminum and specially lined vessels for the petroleum industry. Our associated company, John Thompson Wolverhampton undertake fusion-welded vessels to Lloyds Class 1 specifications in the largest sizes.
JOHN THOMPSON (DUDLEY) LIMITED
DUDLEY, WORCESTERSHIRE
JOHN THOMPSON (DUDLEY) LIMITED
JOHN THOMPSON GROUP

JOHN THOMPSON (DUDLEY) LTD - DUDLEY - WORCS

DP/1

Proof again—the best costs you less!



Heated oil storage tanks, Murphy Miles Oil Co., Chicago

17 Years without maintenance for these *Insul-Mastic* coated tanks

Ordinary asphaltic coatings can't possibly stand the test of years like Insul-Mastic "Gilsonite" coatings — and you can't ever be sure ordinary coatings are protecting against metal damage, or merely hiding it.

Understandably, Insul-Mastic costs a little more initially, but you can't find a better system for preventing corrosion, sealing out moisture, vapor sealing or handling the many specialized insulating requirements of industry. The proof is in the hundreds of installations like Murphy Miles Oil Co. where Insul-Mastic coatings continue to give the same *complete* protection they gave back in 1939. Your Insul-Mastic Representative will provide complete details without obligation.

6 year exposure shows Insul-Mastic (left) unchanged. Ordinary mastic (right) shows shrinkage and deterioration that breeds metal damage.

GILSONITE
makes the difference

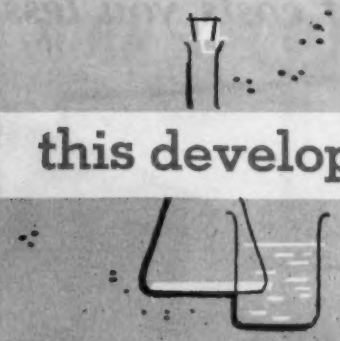
Gilsonite is one of the most resistant of all materials used for protective coatings. It is composed of highly complex hydrocarbons saturated to the limit of their capacity, not susceptible to displacement by other elements nor to combination with acids and alkalis, nor to oxidation for many years by exposure to the atmosphere. It is better than 99.5% pure, being entirely free from volatiles and other short-lived impurities. For years *Insul-Mastic Gilsonite content has been far greater than any other mastic. Many contain no Gilsonite!*

MAIL THIS COUPON TODAY TO:
INSUL-MASTIC CORPORATION OF AMERICA
7756 West 61st Place, Summit, Illinois
☐ Send information ☐ Have Representative call

Name_____ Title_____
Company_____
Address_____
City_____ State_____

Think first of the coatings that last!

Insul-Mastic
CORPORATION OF AMERICA
7756 WEST 61st PLACE SUMMIT, ILLINOIS



this development of a research idea . . .

helps make

This picture shows the business end of a bright idea for gasolines. It is the heart of the UOP Rexforming process, a new development in petroleum refining that produces automotive gasolines with the industry's highest octane ratings.

The idea was born in our research laboratories. The equipment necessary to make the process commercially practical was developed by UOP design and process engineers.

A lot of scientists, technicians and engineers spared neither brains nor labor in bringing this idea to its successful practical application. And back of it all was the basic purpose of making the gasolines you sell meet today's demand for more efficient motor fuels and perfecting the methods to make its manufacture efficient and economical.

Not only at UOP, but throughout the petroleum industry "men of science" are constantly working to provide the "men who sell" with more marketable products from petroleum. They, too, have an important part in the great economic process of creating demand by making supply more salable.

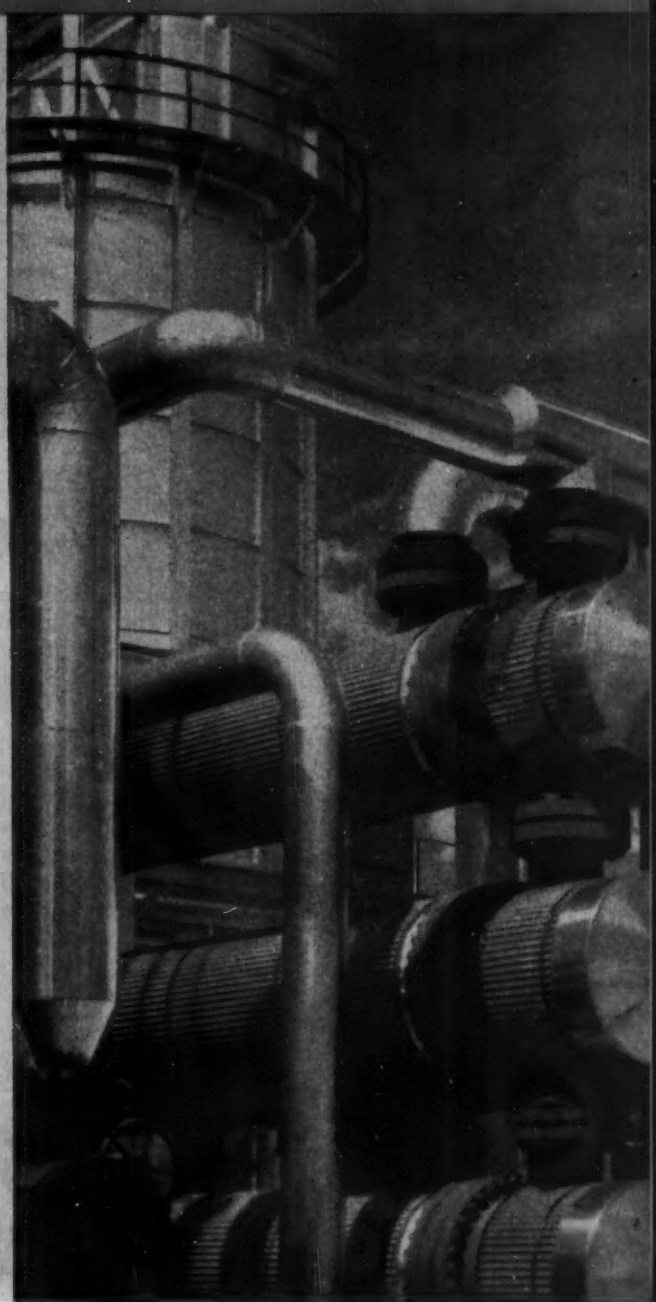
UOP has prepared an interesting booklet on "How Men of Science Help You Sell". We'll be glad to send you a copy on request.

UNIVERSAL OIL PRODUCTS COMPANY

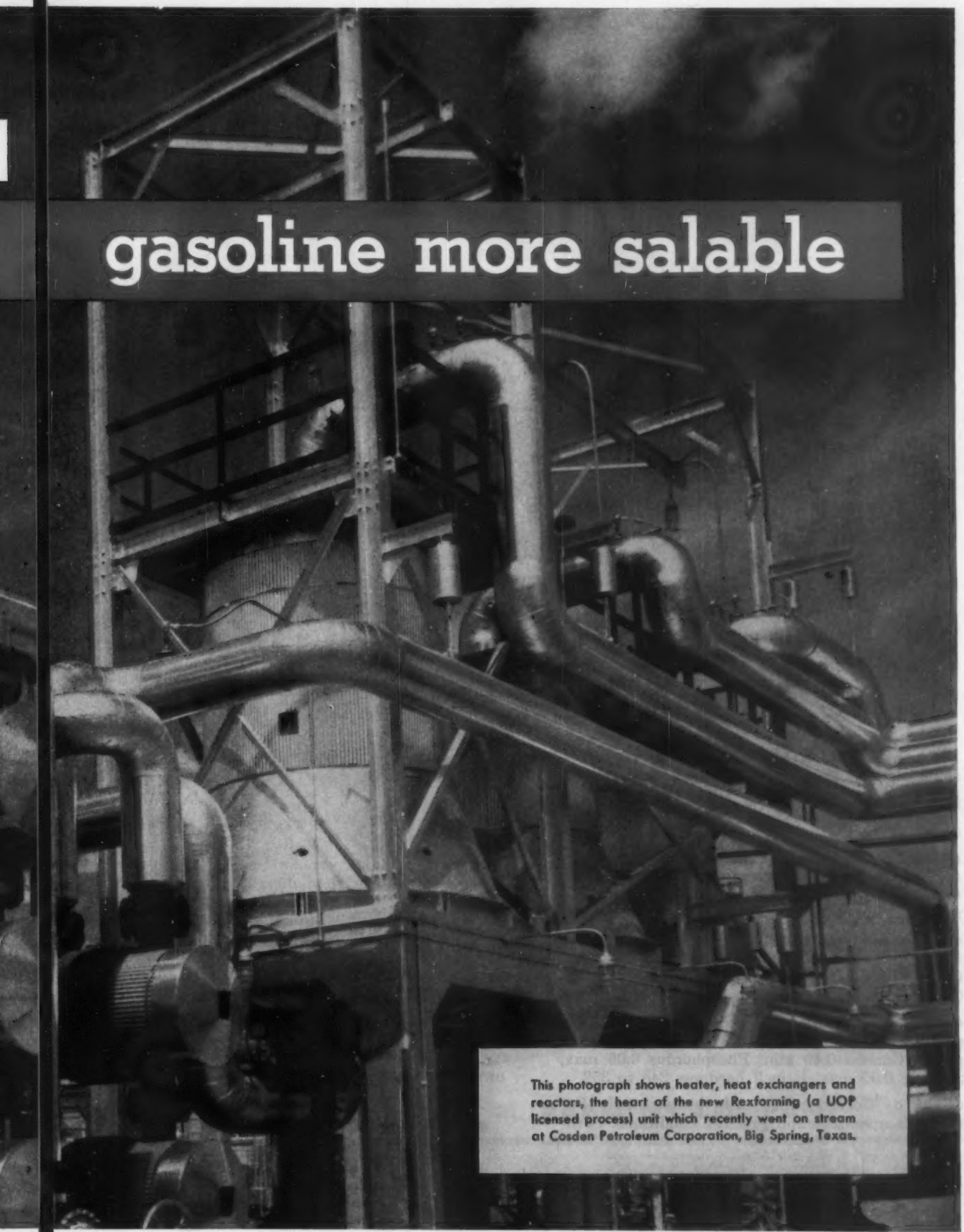
UOP

30 Algonquin Road
Des Plaines, Illinois, U. S. A.

Forty Years Of Leadership In Petroleum Refining Technology

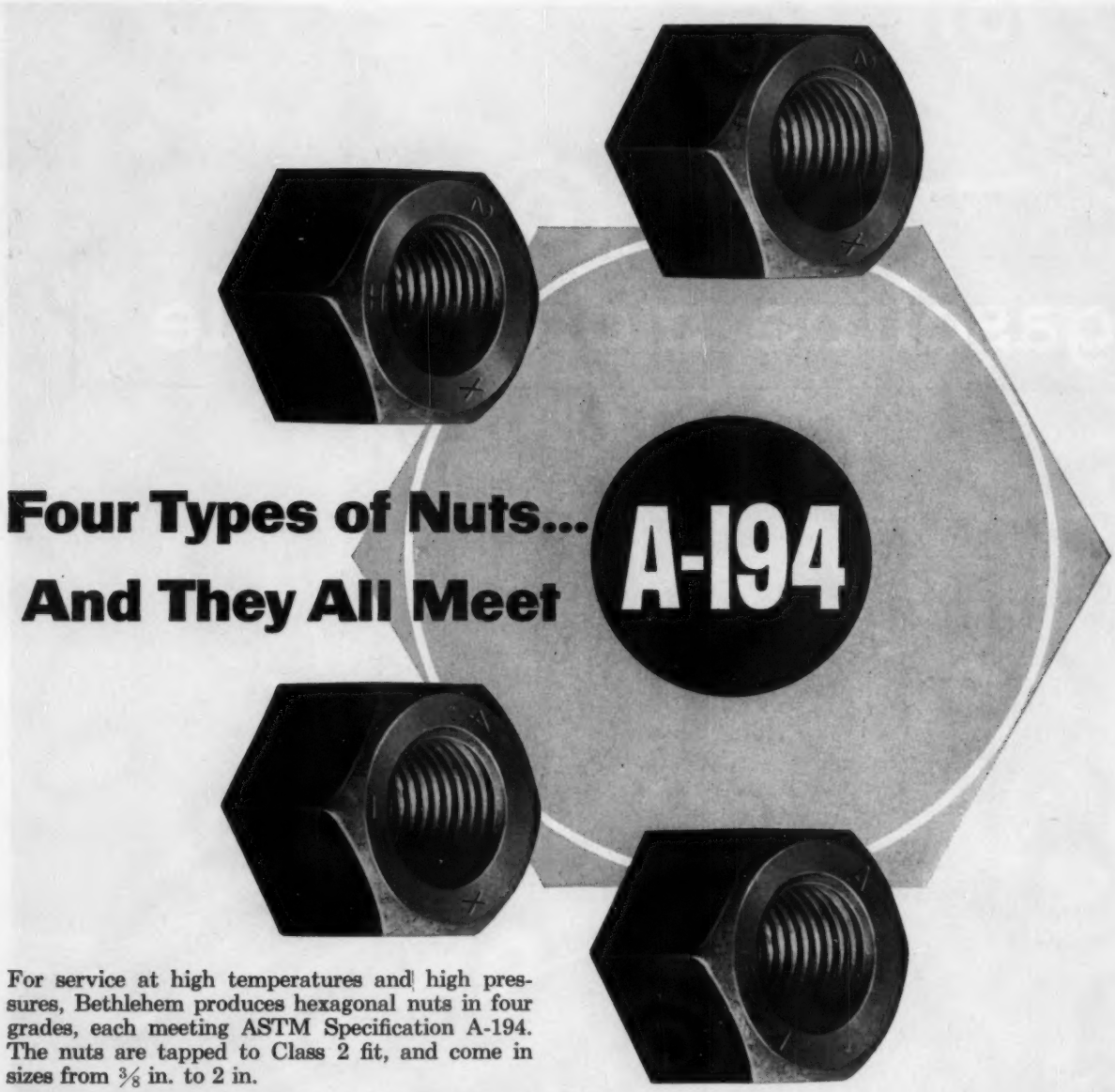


gasoline more salable



This photograph shows heater, heat exchangers and reactors, the heart of the new Rexforming (a UOP licensed process) unit which recently went on stream at Cosden Petroleum Corporation, Big Spring, Texas.

For more data on advertised products, use Readers' Service Cards, last page.



Four Types of Nuts... And They All Meet A-194

For service at high temperatures and high pressures, Bethlehem produces hexagonal nuts in four grades, each meeting ASTM Specification A-194. The nuts are tapped to Class 2 fit, and come in sizes from ⅜ in. to 2 in.

GRADE 1 Low-carbon steel. Suitable for non-critical applications; also for use at moderately elevated temperatures. Carbon 0.15 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness 120 min.

GRADE 2 Medium-carbon steel, specially intended for use at moderate temperatures and pressures. Carbon 0.40 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness is 160 min.

GRADE 2H Excellent for high-temperature, high-pressure service because it is quenched and tempered. Carbon 0.40 min, Phosphorous 0.05 max, Sulphur 0.05 max. Brinell hardness 248 to 352.

GRADE 4 Molybdenum steel, heat-treated. For severe temperature and pressure conditions. Bethlehem Grade 4 nuts are also ideal for sub-zero service, their 4L marking indicating they meet the impact requirements of Spec. A320 for low-temperature bolting. Nut has minimum Charpy impact value of 15 ft-lb down to —150 F. Carbon 0.40 to 0.50, Manganese 0.50 to 0.95, Phosphorous 0.04 max, Sulphur 0.05 max, Silicon 0.15 min, Molybdenum 0.20 min. Brinell hardness 248 to 352.

If you would like to have additional information, just drop a line to the nearest Bethlehem office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Pride in our Customers

During the past year we have served some of the finest customers in the world. A few of them in the Petroleum and Chemical Industries are listed here. Our wish to all is continuing success.

PARSONS

THE RALPH M. PARSONS COMPANY

NEW YORK
PASADENA
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BAGHDAD
BEIRUT
JEDDAH
KARACHI
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ENGINEERS • CONSTRUCTORS
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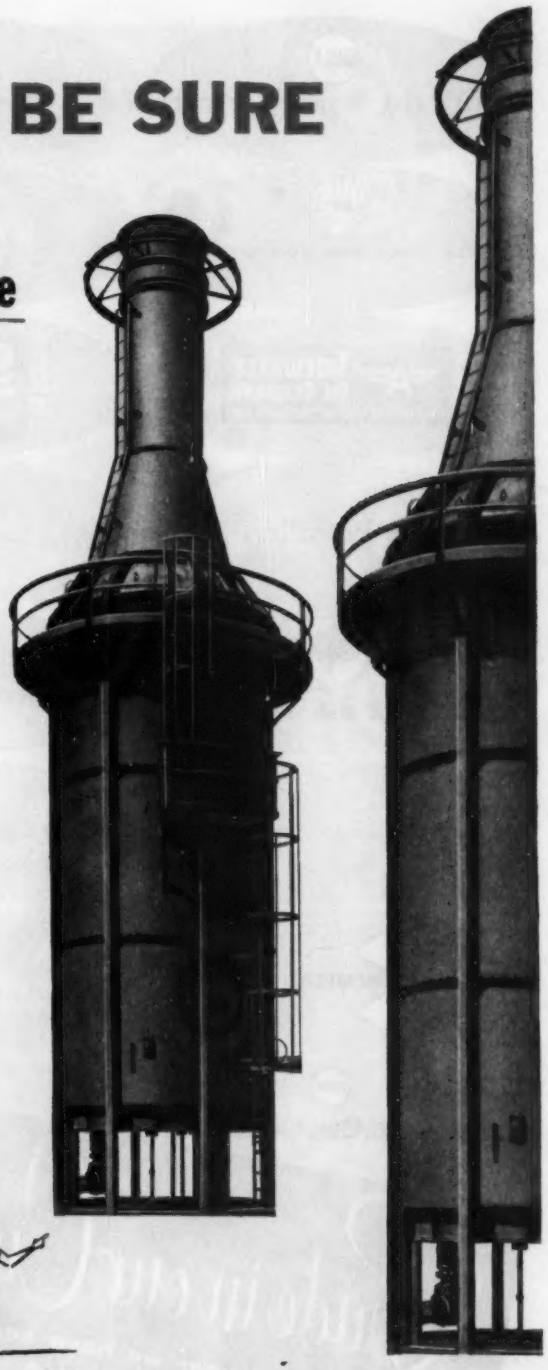
YOU, too, CAN BE SURE

petrochem-isoflow furnaces

are most economically desirable

by any comparison

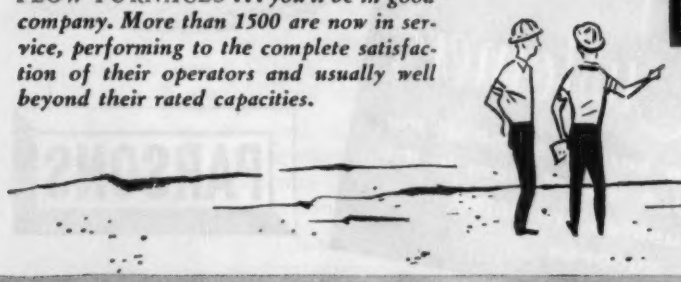


Whenever *all* the specifications and *all* the operating requirements are applied to direct-fired furnace design, you can be sure PETROCHEM-ISOFLOW FURNACES will be found most economically desirable, by any comparison.

In making comparisons it is essential to take these factors into consideration:

1—Average radiant transfer rate.
2—Maximum deviation from average radiant transfer rate.
3—Average and maximum transfer rate in convection section.
4—Maximum tube wall temperature, radiant or convection.
5—Maximum efficiency with specified excess air.
6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube.
7—Overload and corresponding transfer load.
8—Design to provide: structural column supports—Ladders—Platforms—Tube Removal facilities, etc.
9—Degree of assembly; of the furnace structure and of the heating surface.

When you specify PETROCHEM-ISOFLOW FURNACES ... you'll be in good company. More than 1500 are now in service, performing to the complete satisfaction of their operators and usually well beyond their rated capacities.



PETROCHEM-ISOFLOW FURNACES

UNLIMITED IN SIZE ... CAPACITY ... DUTY

PETRO-CHEM DEVELOPMENT CO., INC. • 122 EAST 42nd St., New York 17, N. Y.

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D
No matter
how you figure . . .
Davison's catalysts
give you more!
• Davison gives you quality
• Davison gives you service
• Davison's high stability catalysts save you dollars.
That's why Refinery Men know that when they buy
Davison they buy dependability in service and product.
DAVISON CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland
Sales Offices: Chicago, Ill.; Houston, Texas; New York, N. Y.;
Baltimore, Md.; San Francisco, Calif.
In Canada: Davison Chemical Company Ltd., Toronto
Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple
Superphosphates, Phosphate Rock, Silica Gels and Silicafluorides.
Sole Producers of DAVCO® Granulated Fertilizers.

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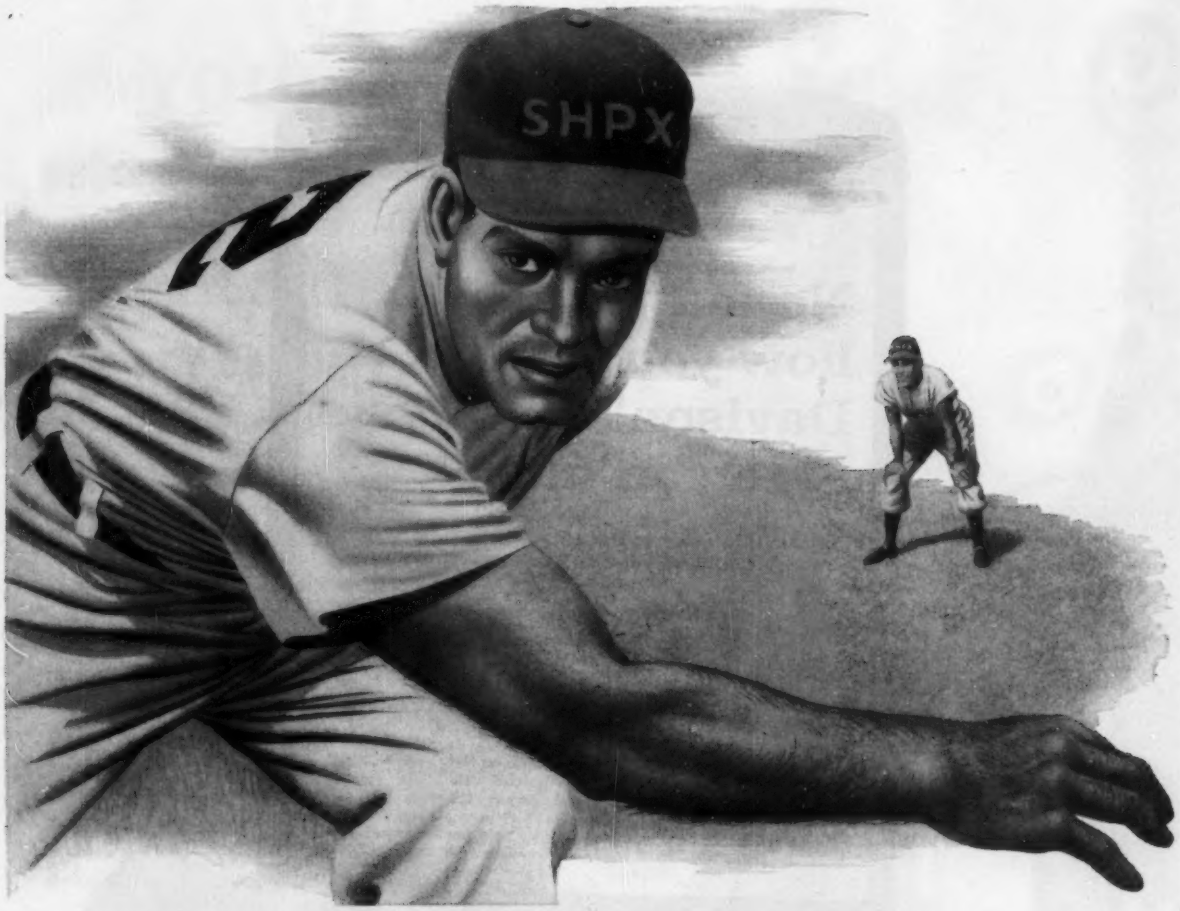
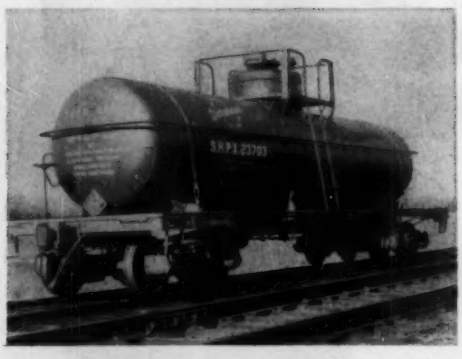


Very Special Delivery



Typical DURADOME . . . designed for vinyl acetate service.

EVERY HOUR, day and night, specially-designed DURADOME tank cars are rolling — their *built-in* protection providing for the safe delivery of industry's liquid products.

This *Very Special Delivery* is *not* a luxury. Millions of miles of profitable experience have proved that DURADOME tank cars *more* than pay their way.

If your bulk liquids call for special care, consult Shippers'. As lessors and exclusive sales agents for ACF-built DURADOME tank cars, Shippers' offers you the finest tank cars built — and provides the help you need to solve *your* shipping problems.

As transportation specialists, SHPX keeps its tank cars at peak efficiency through a network of offices and repair shops from coast-to-coast.

Contact your nearest Shippers' representative. He'll give you the facts on SHPX *Very Special Delivery*—and help you decide whether lease or outright purchase is your best investment.

SHIPPERS SHPX CAR LINE

SHIPPERS' CAR LINE

DIVISION OF ACF INDUSTRIES, INCORPORATED

30 Church Street, New York 7, N. Y.

CHICAGO, ILL. • HOUSTON, TEX. • SAN FRANCISCO, CAL. • MILTON, PA. • EAST ST. LOUIS, ILL. • SMACKOVER, ARK. • TULSA, OKLA. • NORTH KANSAS CITY, MO. • RED HOUSE, W. VA.

This seal on an air-compressor spells SAFETY from lubricant-caused fires and explosions

If you are operating one, ten or fifty air compressors in your plant, here's big news for you. The day of lubricant-caused compressor fires and explosions is *over!*

Now there's a new chemically tailored compressor lubricant called Pydraul AC that not only lubricates like a premium-grade petroleum oil—*it's fire-resistant!*

You'll realize additional savings in Pydraul AC's ability to minimize carbon deposits on air-compressor exhaust valves and air piping systems.

No conversion problems—just drain your flammable lubricant and replace with fire-resistant Pydraul AC—it's that easy.

Service-proved—two years of industry-wide service have confirmed Pydraul AC's *safety* and operating economies for power plants, gas transmission, chemical processing and the basic metalworking industry.

There's a fire-resistant Pydraul for every industrial hydraulic job: general-purpose Pydraul F-9; Pydraul 150 and Pydraul 60 for use in precision equipment; and Pydraul 600 for heavy equipment.

Pydraul: Reg. U.S. Pat. Off.

Write today for your copy of Pydraul AC bulletin.
Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. PAC-73, 800 N. 12th Blvd., St. Louis 1, Mo.

MONSANTO®
WHERE CREATIVE CHEMISTRY WORKS WONDERS FOR YOU

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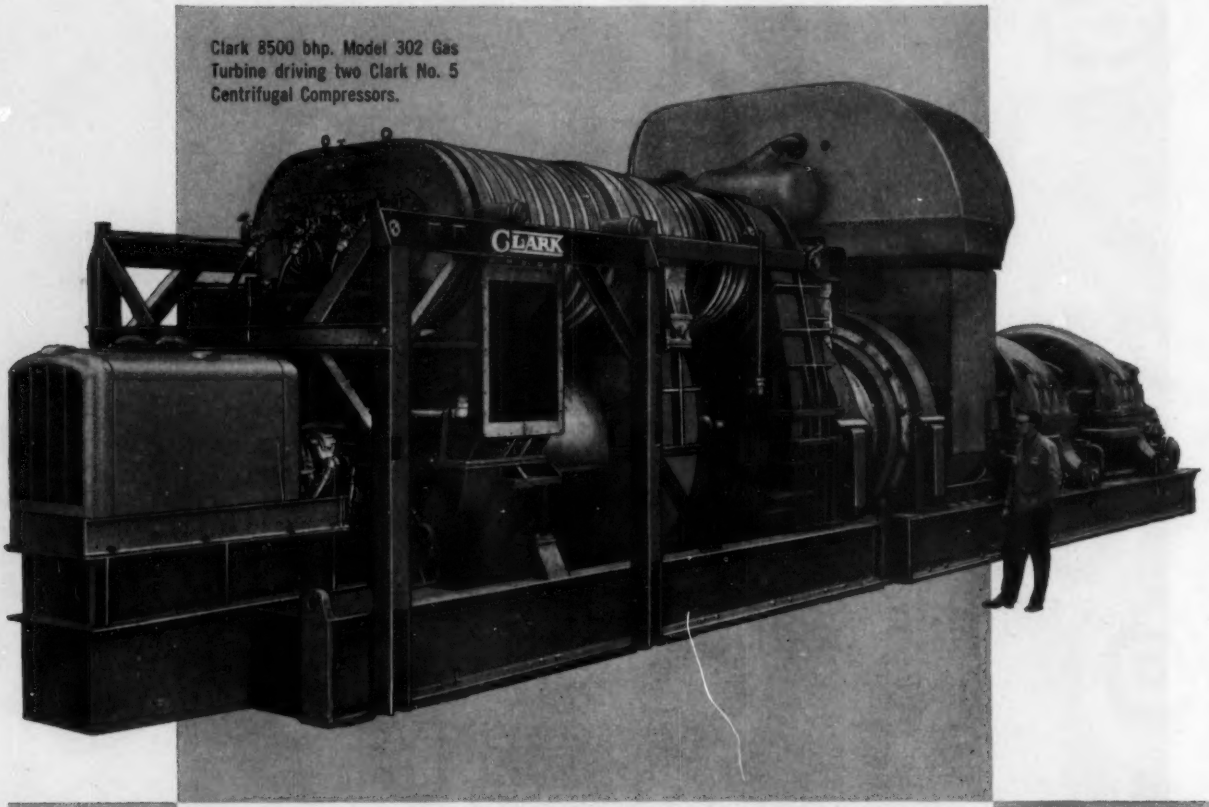
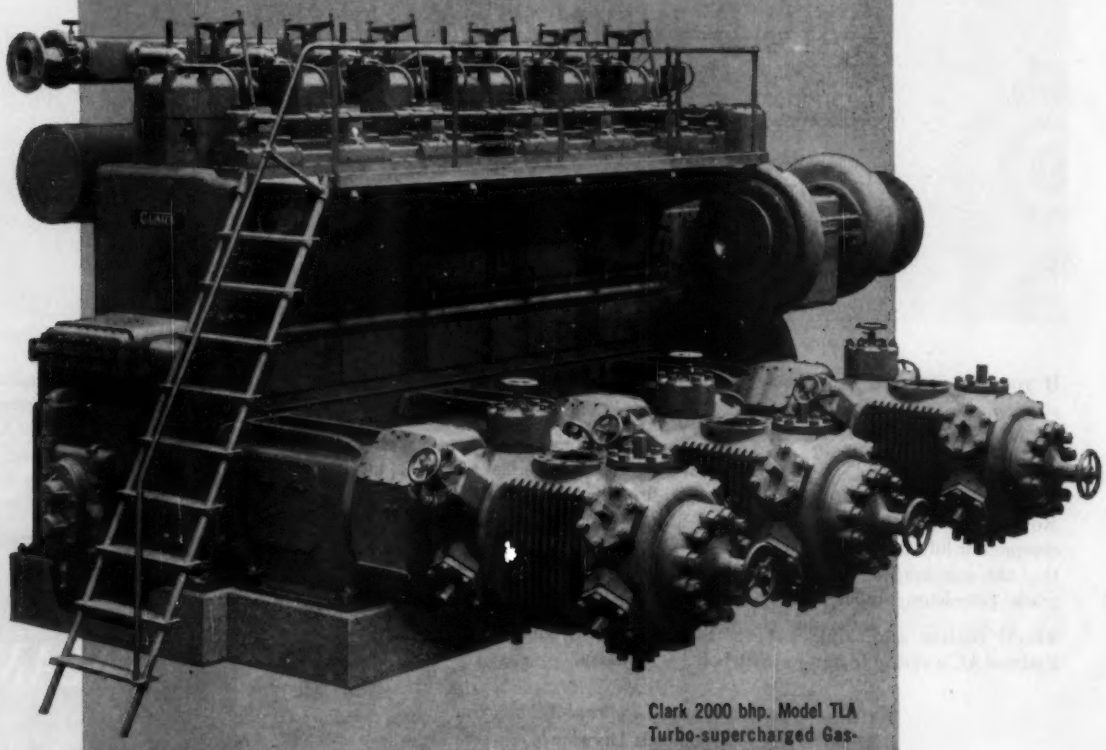


Clark 8500 bhp. Model 302 Gas Turbine driving two Clark No. 5 Centrifugal Compressors.



Clark 2000 bhp. Model TLA Turbo-supercharged Gas-Engine-Driven Compressor.

Gas turbines or engines?

With Clark you eliminate

Prejudice

Gas turbine-driven centrifugal compressors or reciprocating compressors . . . you can get both types from Clark

Prejudice can add substantially to the cost when selecting compressors. At Clark, we build both gas turbine-driven centrifugal compressors and gas-engine-driven reciprocating compressors. In both instances the compressors and drivers are the most modern available.

Our chief concern is to be certain that you obtain the proper unit for your specific installation. This is where our experienced application engineers enter the picture. Both types of units have certain characteristics that may make one or the other best for your particular use. An unbiased opinion, after a careful examination of all the facts and conditions, is vitally important. Clark is the only company that can give you an unbiased opinion because Clark is the only company that builds reciprocating and centrifugal compressors in addition to gas turbines.

Clark application engineers will be pleased to help you determine the right type of compressor and driver combination for your next application.

CLARK BROS. CO., OLEAN, NEW YORK
One of the Dresser Industries
Offices in Principal Cities Throughout the World

CLARK

Centrifugal Compressors
Reciprocating Compressors
Gas Turbines

For more data on advertised products, use Readers' Service Cards, last page.

Tomorrow's Challenge

Meeting the challenge of tomorrow demands advanced designing, engineering and construction methods. It calls for greater investment in superior facilities at home and abroad to produce new and improved processes and techniques. All these are needed to secure and extend the greatest markets of our time.

The REFINERY ENGINEERING Company is meeting tomorrow's challenge *today* with its broadening versatility; its expanding equipment, staff and area of operations. Oil refining, petrochemical and rare earth and ore industries are offered a complete service, from basic research through site selection, design, engineering and construction — *anywhere*. This is backed by ample financial resources to assure on-schedule completion of any project. A discussion of your proposed expansion is invited.

TREC Co.

A DIVISION of VITRO CORPORATION of AMERICA

The REFINERY ENGINEERING Company

NEW YORK TULSA TORONTO

you can meet any lubrication standard if you

BLEND WITH ENJAY PARANOX®

(DETERGENT-INHIBITOR ADDITIVES)

Blended with Paranox, lubricants can be compounded to combine *both* minimum wear and maximum engine cleanliness characteristics. That's why more and more refiners and blenders are relying *exclusively* on Paranox in formulating lubricants for heavy duty equipment and all engines that are subjected to tough operating conditions.

Through years of intensive research and development work with manufacturers and oil companies, Enjay has developed the only *complete line* of high quality additives (Paramins®) that can assure *maximum* performance characteristics. Why not let this experience and know-how work for *you*? Write, wire or phone the Enjay Company today.

ENJAY

Pioneer in Petrochemicals

ENJAY COMPANY, INC., 15 WEST 51st ST., NEW YORK 19, N. Y.

Akron • Boston • Chicago • Los Angeles • New Orleans • Tulsa

A PRIME OUTLET FOR GOOD PUBLIC RELATIONS

and a desperately-needed public service

One of the most effective public relations jobs ever accomplished was achieved last year by hundreds of companies and individual businesses of every size.

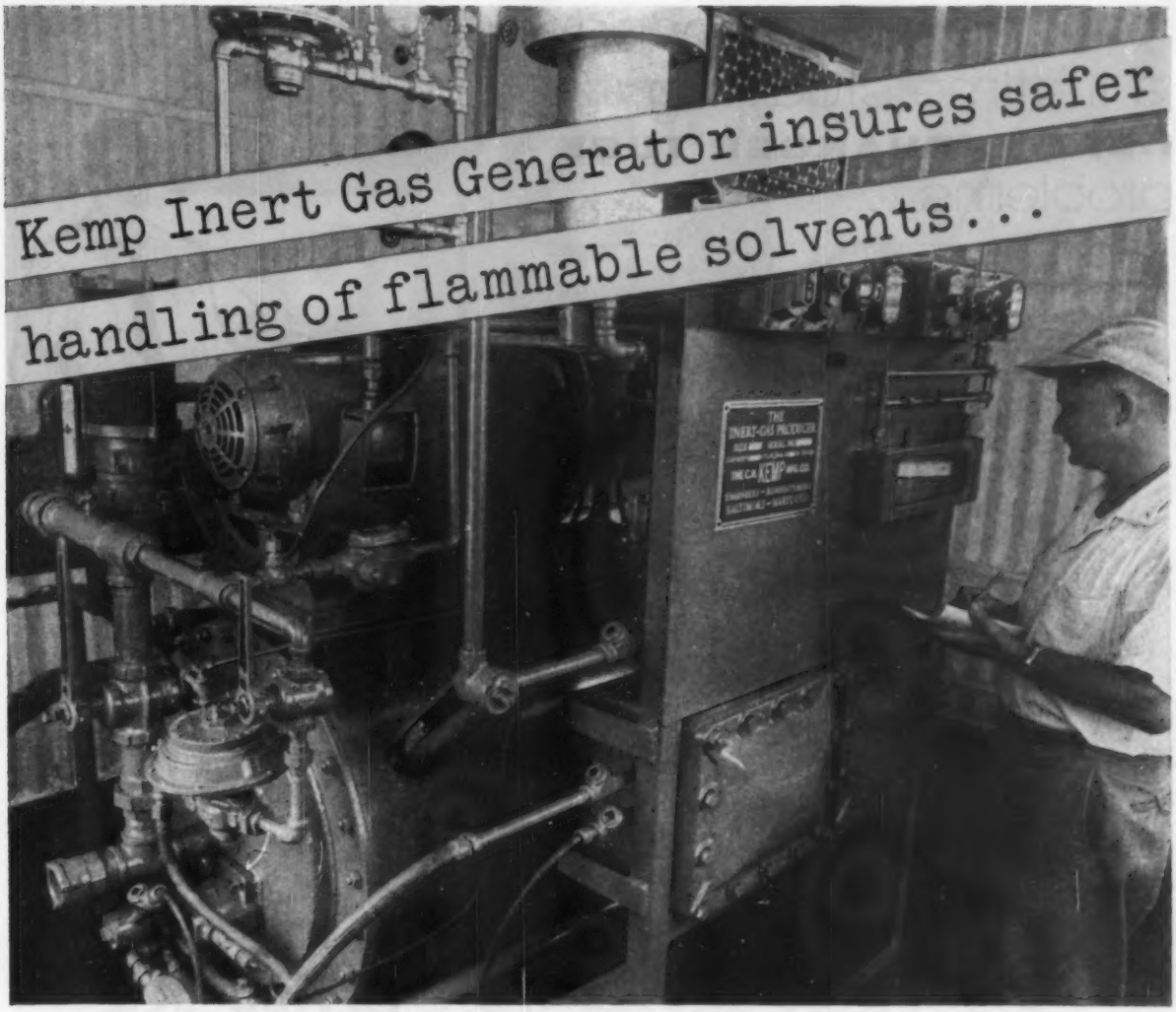
These companies have been helping to sustain an advertising campaign that performs a desperately-needed public service: It shows the American people how to drive to stay alive. It also portrays the almost unbelievable fact that more than 40,000 men, women and children were killed in traffic accidents last year—and tells what to do to help stop highway homicide.

The campaign was prepared by a volunteer advertising agency in cooperation with The Advertising Council and The National Safety Council. But the over ten million dollars worth of time and space which carry the messages to the public was contributed by media owners or sponsored by business organizations, in the public interest.

Your own plans may readily permit the inclusion of such advertising—both from the view of the vital public service it would perform, and the incalculable good will it would promote for your name, your company, and your product or service.

To find out how easily your own program can tie in with this nationwide effort, and for the complete story on who, what, when and where, we sincerely invite you to write to The National Safety Council, Chicago 11, Illinois.

Published in cooperation with
The National Safety Council
The Advertising Council



Quaker State reports:

Kemp Generator maintains steady inert gas supply for blanketing—even under varying load conditions!

In this Quaker State Oil Refinery, in Farmer's Valley, Pa., a Kemp 3,000 cu. ft. per hr. Generator is used to provide inert gas atmosphere to blanket vessels containing flammable solvents. Mr. Joe O. Brown, Process Engineer, says that the Kemp Generator, in use since 1949, is a big improvement over a previous model replaced by this 3-MIHE.

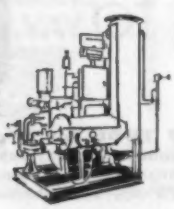
Kemp does all inert gas jobs better

Kemp Gas Generators are easier to operate, start quickly, give continuous output around the clock. Even under fluctuating loads uniform analysis is maintained. Pipelines and vessels can be purged easily, quickly, for cleaning and inspection or when processes are changed! Kemp Generators are also ideal for annealing, hardening, and sintering. Kemp has the ability to produce a chemically clean inert at a specific analysis *regardless* of demand!

Investigate NOW

Find out how Kemp Engineers can provide the most profitable answer to *your* inert gas problem! Write for Bulletin I-10 today.

KEMP
OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • DYNAMIC DRYERS
FIRE CHECKS • METAL MELTING UNITS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland

For more data on advertised products, use Readers' Service Cards, last page.

you, too, could spend
a lifetime studying
HEAT EXCHANGER TUBE
problems...

but there's an **easy** way
to save yourself
that kind of work

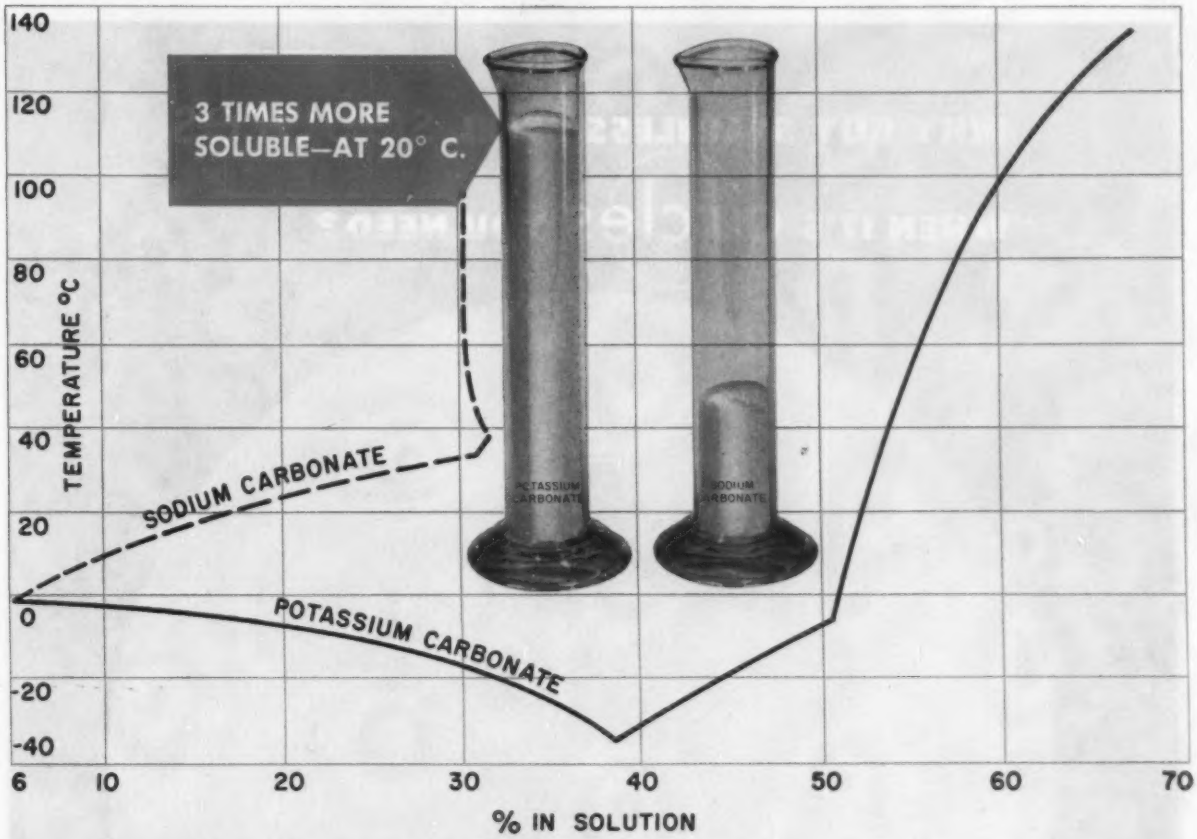
Simply pick the brand of Heat Exchanger Tube that starts out in life as a CONTINUOUS-CAST billet . . . Scovill Phosphorized Admiralty. Only in Scovill's unique continuous casting process do *many* carefully controlled melts of alloy BLEND together in the casting process to produce such SOUND and UNIFORM billets for subsequent hot extrusion and cold-drawing into Heat Exchanger Tube. Exceptional uniformity of chemical composition and uniform distribution of the inhibitor (phosphorus) mean longer tube life.

Scovill Manufacturing Company, Mill Products Division, 99 Mill Street, Waterbury 20, Connecticut. Phone PLaza 4-1171.

simply put it up to... **SCOVILL**

HEAT EXCHANGER TUBE FOR APPLICATIONS FROM MARINE TO PETROCHEMICAL . . . FROM COMPRESSOR INTERCOOLERS TO "CAT-CRACKER" EXCHANGERS . . . IN THESE POPULAR ALLOYS
Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Naval Brass • Red Brass, 85% • Deoxidized Copper
Arsenical Copper • Cupro Nickel 10%—20%—30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

ISC57



For higher solubility...
For more concentrated solutions...
Use Solvay POTASSIUM Carbonate

SOLVAY Potassium Carbonate is 3 times as soluble as sodium carbonate (soda ash) at room temperatures. This higher solubility permits the use and packaging of more concentrated solutions. In addition, the products of reaction with potassium carbonate are more soluble than those with sodium carbonate. Our chart shows the greater range of solubility . . . the wider range of temperatures at which it is effective.

In many fields substantial savings are being made by the switch to SOLVAY *Potassium* Carbonate. With it soap makers can add more builder to liquid cleaners. It also offers advantages in chemical processing, synthesis gas scrubbing, boiler feed-water treatment and cleansing.

Learn how you may apply SOLVAY Potassium Carbonate to your product or process.

Write for samples . . . information!

SOLVAY

Aluminum Chloride • Ammonium Bicarbonate
Potassium Carbonate • Monochlorobenzene
Vinyl Chloride • Calcium Chloride • Soda Ash
Sodium Nitrite • Snowflake® Crystals • Chlorine
Sodium Bicarbonate • Ammonium Chloride • Caustic
Potash • Methylene Chloride • Carbon Tetrachloride
Methyl Chloride • Cleaning Compounds • Caustic Soda • Chloroform
Para-dichlorobenzene • Ortho-dichlorobenzene • Hydrogen Peroxide

Allied Chemical

SOLVAY PROCESS DIVISION
ALLIED CHEMICAL & DYE CORPORATION
61 Broadway, New York 6, N. Y.

Please send me without cost:

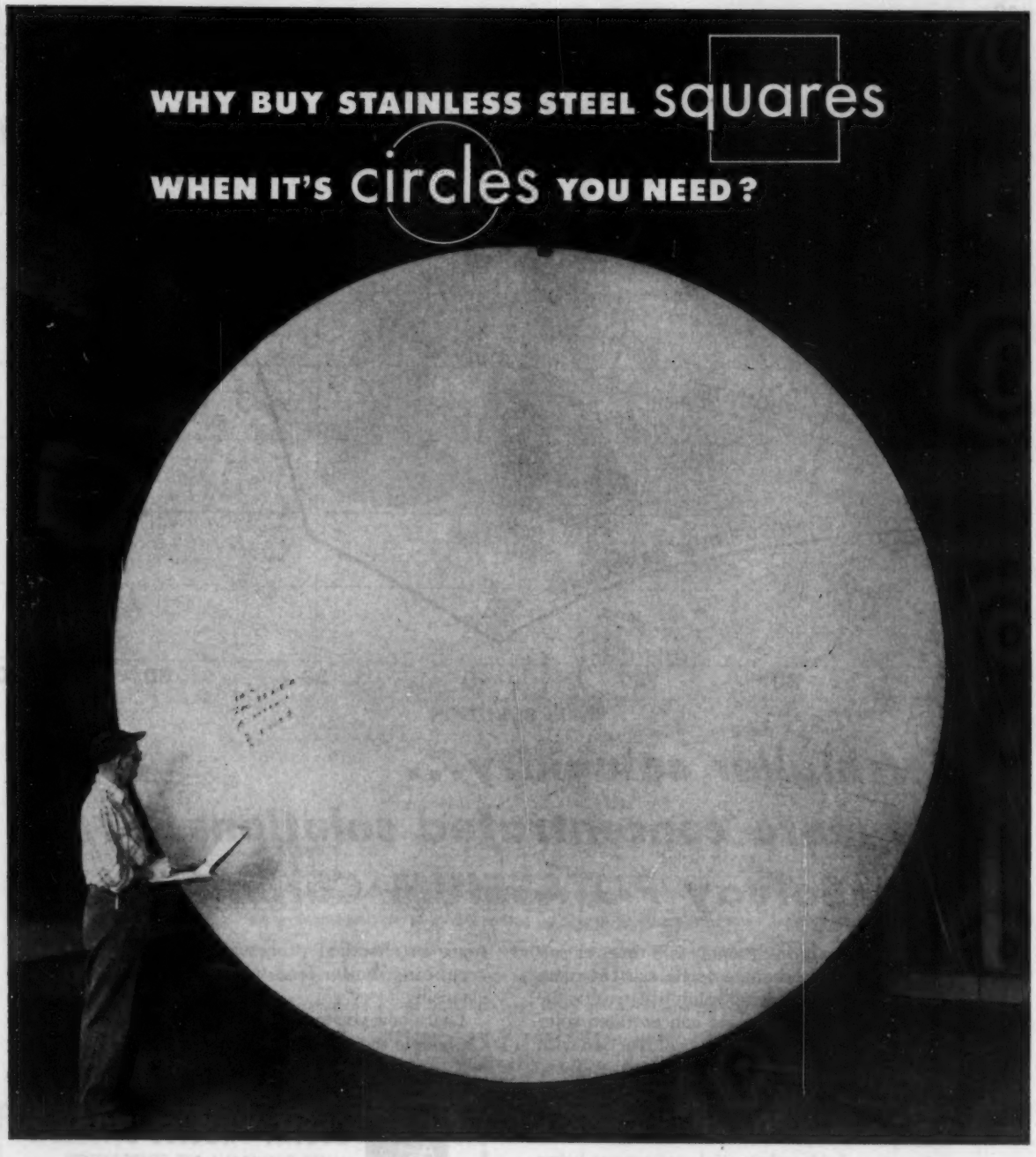
☐ Working sample of SOLVAY Potassium Carbonate
☐ SOLVAY Potassium Carbonate fact book

Name_____
Position_____
Company_____
Address_____
City_____ Zone_____ State_____

ED-3

For more data on advertised products, use Readers' Service Cards, last page.

WHY BUY STAINLESS STEEL squares WHEN IT'S circles YOU NEED?



This circle, 9/16" thick x 164" diameter, is one piece of Type 316L stainless steel. Had the customer ordered a square, he would have paid freight on a half-ton of excess material. Also, he would have had the problem and expense of handling the square and cutting the circle.

Here are four sound reasons why Carlson customers save time and money when they order the circles they want—rather than the squares they have to cut . . .

1. If the gauge and size are circle-shearable, there is no extra charge for cutting the circle. This saves cutting labor and scrap handling expense.
2. If the gauge is such that a cutting charge applies to the square, it pays to order the circle. This eliminates the extra charge for cutting the original square and involves only the one charge for cutting the circle.
3. Because circles weigh approximately 25% less than squares, there's a substantial saving in transportation costs.
4. Small or medium size circles are often available from stock when squares may not be. The delivery time saved can be an important factor.

When you need stainless steel circles, come to Carlson where we specialize in stainless steel . . . that's your guarantee of dependable service.

Stainless Steels Exclusively

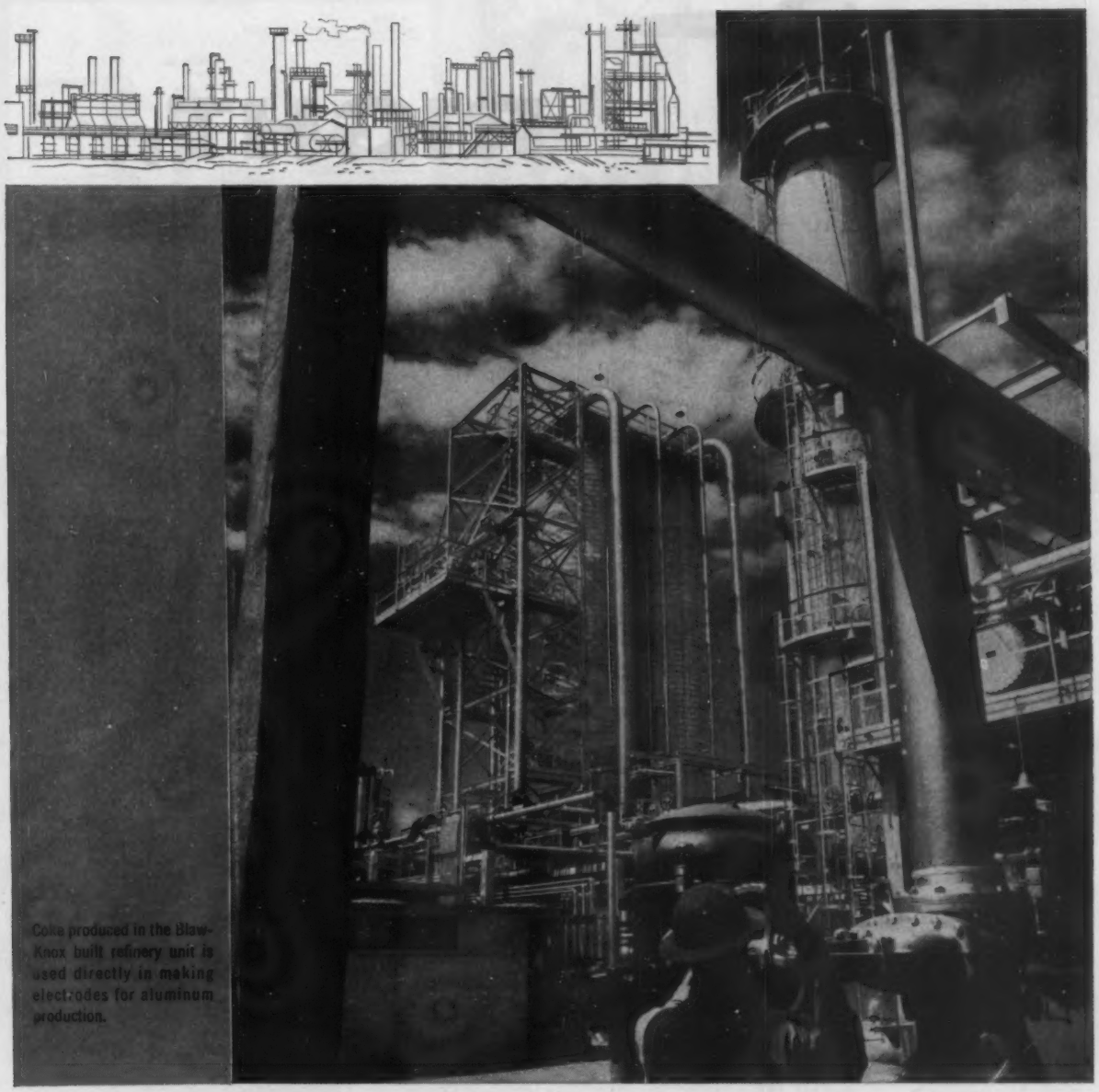
G. O. CARLSON Inc.

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

For more data on advertised products, use Readers' Service Cards, last page.



Coke produced in the Blaw-Knox built refinery unit is used directly in making electrodes for aluminum production.

PETROCHEMICALS

are a growing factor in two great industries ... petroleum and chemicals

Wide experience, gained through long association with diversified problems in both petroleum and chemicals, as well as in petrochemicals, enables Blaw-Knox engineers to meet your most exacting requirements in designing, engineering and building plants in all three process areas. When planning new or expanded facilities, investigate how this specialized background can serve you, too.

BLAW-KNOX

BLAW-KNOX COMPANY

Chemical Plants Division

Pittsburgh 22, Pa. • Chicago 1, Ill.

Birmingham • Philadelphia • New York City • San Francisco • Washington, D.C.

Designers, engineers and builders of plants for the process industries: chemicals • petroleum • petrochemicals • resins and plastics • nuclear energy • fats and oils • fertilizers • synthetic fuels

For more data on advertised products, use Readers' Service Cards, last page.

RIGHT, in every case

CHAPMAN STEEL VALVES

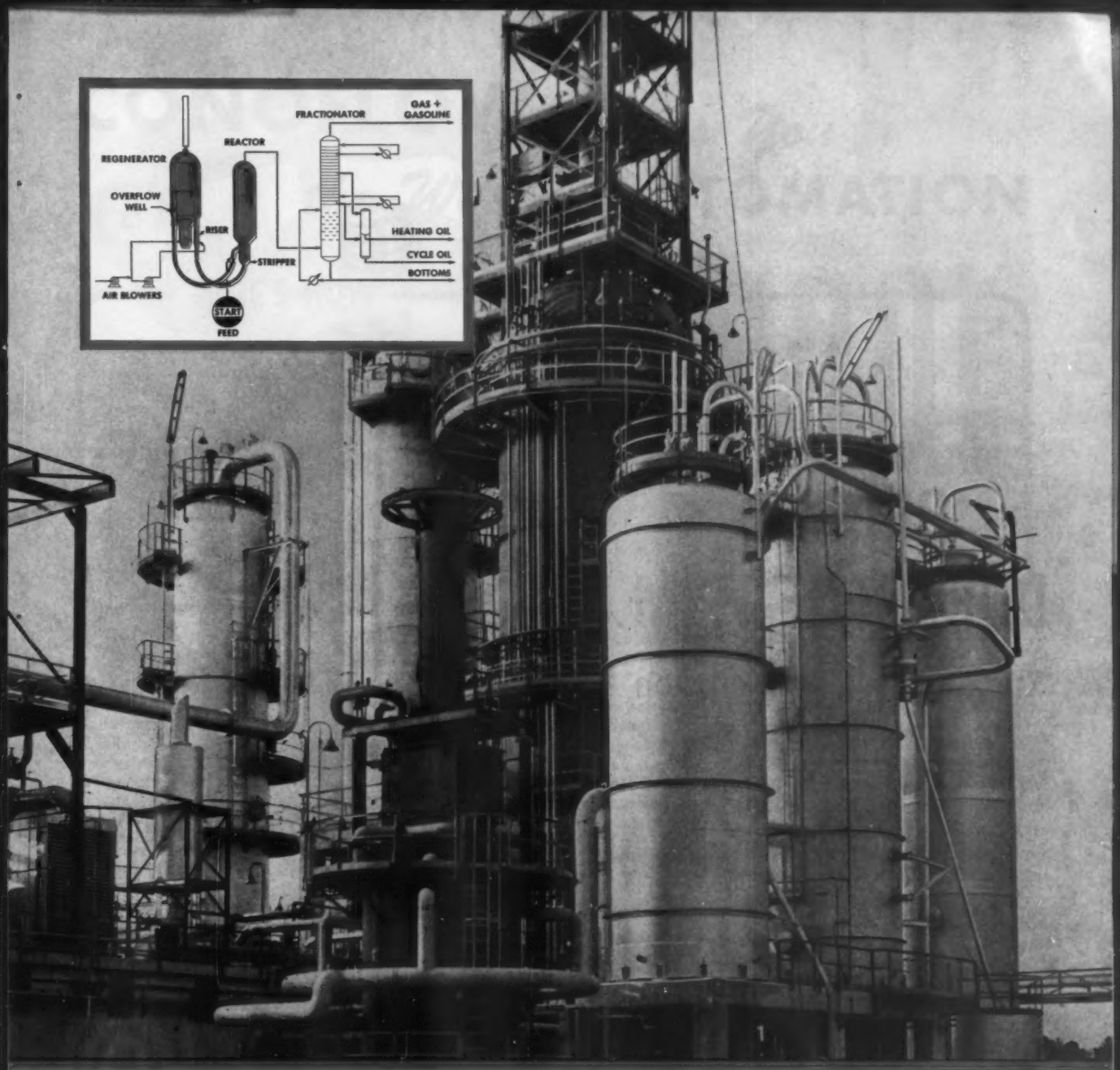
Check them off, one by one. They're all important to you, a user of valves . . . steel valves. You want close tolerances; tight and positive seats; smooth, dependable, operation without jamming, chattering or excessive wear. Even with long service under the most severe conditions you want to cut your maintenance costs to a new rock bottom low.

Name your metal. You can have Chapman Steel Valves in standard alloys for normal requirements . . . or special alloys for extra service conditions. And for *your* benefit, all of these alloys are poured in Chapman's own foundries under rigid technical supervision.

Chapman superior steel valves — gates, globes, checks — are available for all pressure and temperature ranges. You can order them with bolted, welded or pressure seal body and bonnet joints and with flanged or welding ends. They all equal or exceed ASA and API standards in every range.

Why not write now for our complete descriptive catalog No. 20.

THE CHAPMAN VALVE MANUFACTURING CO.
INDIAN ORCHARD, MASS.



10,800 B/D LION OIL CO. DIVISION OF MONSANTO CHEMICAL CO. UNIT, EL DORADO, ARK.

MODEL IV CAN GIVE YOU FLUID CATALYTIC CRACKING AT LOWEST INVESTMENT COST

Esso Research and Engineering Company offers you *Model IV*, the simplest and most stable *Fluid Catalytic Cracking* process yet developed. The lower investment, maintenance and operating costs of the *Model IV Fluid Catalytic Cracker* are another achievement of the Esso Research program — 38 years of new process developments made available to refiners around the world.

A new compact catalyst transfer system with smaller-sized vessels lowers over-all height and uses far less structural steel. Slide valves are eliminated — inherent self-stability and easy recovery from upset result in long run lengths.

First *Model IV* unit on stream was erected under license in 1952. Twenty-four *Model IV's* have since gone on stream — more than half of their capacity under license. Nine more units are in the construction or planning stage. Flexible *Model IV Fluid Catalytic Cracking* can play an important part in helping you meet changing market demands. We would welcome your inquiry.

ESSO RESEARCH AND ENGINEERING COMPANY

15 West 51st Street, New York 19, N. Y.

Your key to progress... an Esso Research process

1000 BRINELL DURACASE TRIM...

Stops galling and erosion

Since the introduction of OIC's Duracase Trim, many forged steel valve specs are obsolete. This 13% chrome stainless steel trim with 1000 Brinell, case-hardened wedges and discs assures positive protection against even the simultaneous attack of the three valve-destroying agents—corrosion, erosion, galling.

OIC offers you a choice of two modern body-bonnet connections—union ring or bolted bonnet—on its entire forged steel gate, globe, angle, and check valve line.

In addition, gate valves offer a choice of standard-flow or high-flow body ports, both with 1000 Brinell wedges.

Step up your valve requirements to the modern high-quality standards reflected in OIC valves. Include OIC on your next specification.

For OIC forged steel valve specification literature, write for Forms No. 195 and 195-R.

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

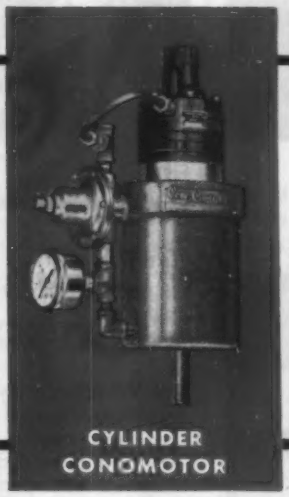
OIC VALVES

FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES

CONOFLOW *Shows You the Way to* AUTOMATION

HERE'S HOW

YOUR PROCESSING EQUIPMENT + INSTRUMENT +

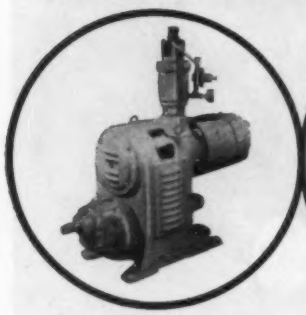


= COST-CUTTING AUTOMATION

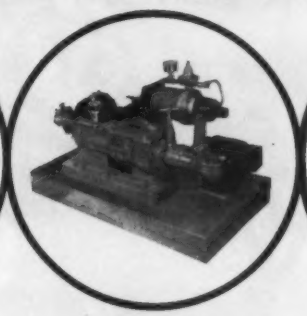
The Conoflow Cylinder Conomotor—a powerful pneumatic actuator—has accelerated industry's approach to the automatic factory and the continuous process plant. A wide range of final control elements, never before available, has been created by the Cylinder Conomotor, a servo capable of following the exact signal outputs of modern electronic and pneumatic instruments.

Cylinder Conomoters, acclaimed by industry as the ultimate in control valve actuators, are fast becoming the standard for automatic control of other process regulating equipment. A few of these are: motor driven speed changers, proportioning pumps, flow regulators, electric timing devices, and numerous electrical systems components such as rheostats, autotransformers and potentiometers.

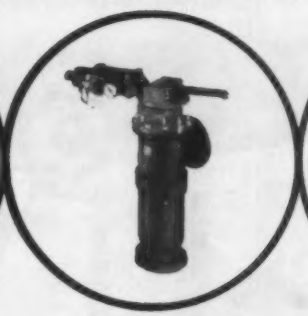
A FEW EXAMPLES OF CONOFLOW AUTOMATION . . .



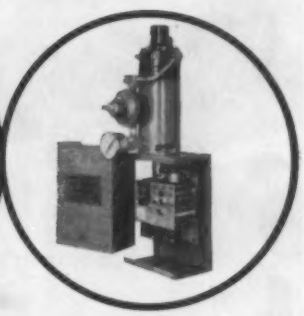
U.S. Electrical Motors
Variable Speed Drive



Proportioneers
Proportioning Pump



Kates
Flow Regulator



Dorr-Oliver
Electric Timer

Conoflow application engineers, well versed in systems engineering methods, will gladly help you evaluate the use of the Cylinder Conomotor on your equipment. Avail yourself of the tremendous advantages offered by this concept of automation, including increased productivity . . . savings in man power . . . improved quality control . . . and many other benefits. Call or write today for "personalized" service. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa. Representatives in principal cities.

WRITE FOR BULLETINS B-50-2-A AND EB-2-A

CC-700

Cono-Controls®

CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

Subsidiary of Walworth

ADSCO

ENGINEERED HEAT EXCHANGERS

● Whether they are manufactured to the customer's specifications or to our own recommended designs, ADSCO-Engineered Heat Exchangers are carefully designed and constructed to deliver their full rated capacity and to perform in accordance with the customer's process needs. Consult ADSCO's engineering department for recommendations, drawings or estimates on heat exchangers which meet your specific problem.

Shown above, thermosyphon reboiler; float-head, removable bundle type, for refineries at Westville, N. J., and Lawrenceville, Ill.

ADSCO ENGINEERED PRODUCTS

ADSCO INDUSTRIES, INC.

EASTERN PLANT
Alberger Heater Division
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WESTERN PLANT
California Steel Products Division
BARRETT AVE., RICHMOND, CALIF.

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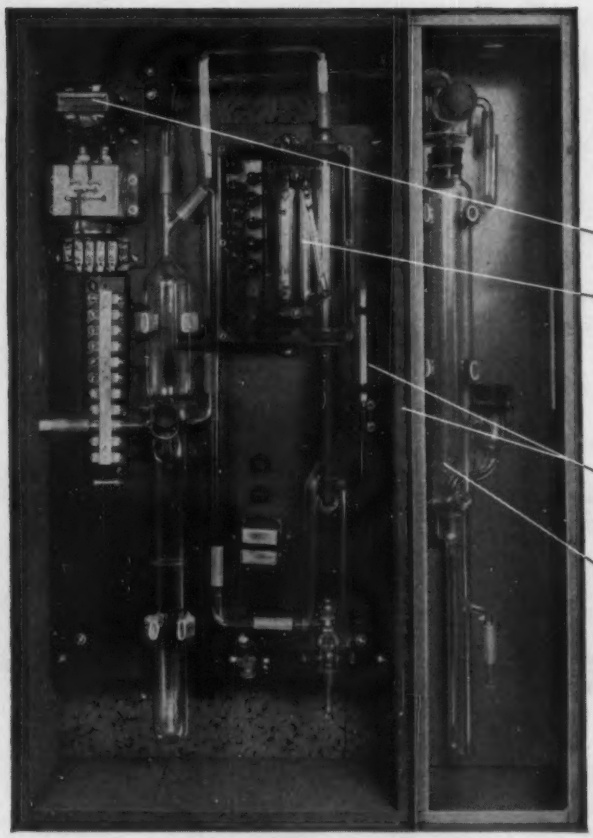
Gas Analysis a problem?

SOLVE IT PERMANENTLY WITH EQUIPMENT WHICH GIVES YOU THESE 7 ADVANTAGES



Thermal Conductivity Analyzer

In hundreds of plants, L&N's Thermal Conductivity Gas Analyzers are solving the problem of obtaining accurate, reproducible measurements of CO_2, SO_2, H_2 in N_2 and many other gases. Because they embody the benefits of thirty years' experience in process gas analysis applications, L&N Thermal Conductivity Analyzers . . . . .

1. Eliminate gas measurement upsets. A constant voltage regulator excludes a-c power variations.

2. Provide accurate measurements by using the unique L&N cell design which gives you vibration-free operation due to a rigid filament support . . . electrical stability by using a platinum filament . . . high corrosion resistance due to glass coating of the filament . . . and immunity to small flow variations because the cell is designed to utilize the gas diffusion principle.

3. Make reproducible measurements possible. Ambient temperature swings are eliminated by enclosing cell assemblies in an insulated case with thermostatically-controlled temperature.

4. Permit low maintenance and therefore minimum downtime as a result of the time-tested analyzer design including features such as flexible junctions, heavy glass construction, etc. Coal and asbestos filters remove mist and dust to assure cleanliness of the analyzer system.

5. Match the inherent accuracy and sensitivity of null-balance Speedomax®G and H Recorders.

6. Permit selection of the particular type of control forms to fit the process. These include electric control, electro-pneumatic, and all-pneumatic controls—each designed to work with the Analyzer-Recorder system for maximum throughput.

7. Gives you undivided responsibility. The entire thermal conductivity system . . . sampling system, analyzer, recorder-controller . . . is designed, engineered and built by one organization with a nation-wide sales and service staff.

These "plus" features of L&N's Thermal Conductivity Gas Analyzers can help satisfy your demands for top quality products which lead to substantial savings. An eight-page booklet, Folder ND46-91(6) giving data on this equipment, is available by writing to Leeds & Northrup Company, 4923 Stenton Avenue, Phila. 44, Pa.

Speedomax H Series 60 Electric Control

Speedomax G Series 60 Electro-Pneumatic Control

Speedomax G Pneumatic Controller

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

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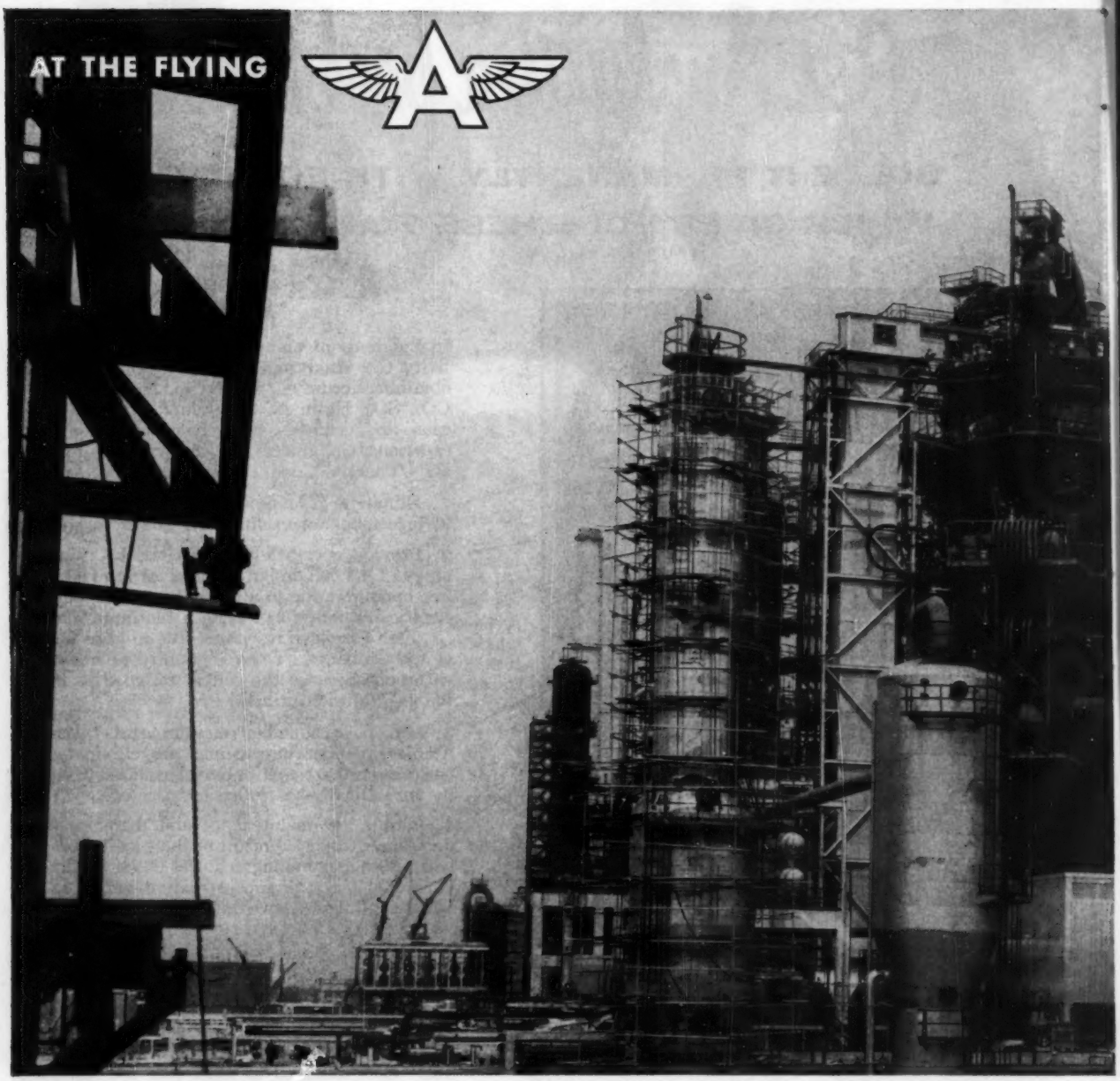

Each a towering problem solved with

NEW TIDEWATER DELAWARE FLYING A REFINERY TAKES 12 TYPES—1,800 TONS

Choosing from the widest range of such materials available from any source, designers and fabricators for Tidewater carefully selected Lukens clad and alloy steels for the heart of its new Delaware Flying A Refinery.

To resist the corrosive attack of sulfur compounds and naphthenic acid—Lukens stainless clad types 316-L, 405 and 410; for chlorides—Lukens Monel-clad; for high-temperature service—Lukens A-204 alloy; to resist hydrogen attack and graphitization and for strength at high temperatures—Lukens A-301 alloy.

And for economical protection against a variety of other corrosive and abrasive problems Tidewater chose 6 additional types of Lukens clad steels—Inconel, nickel and copper; 304, 304-L and 316 stainless.

Lukens clad steels offer all the protection of solid high alloy—economically. The bond is permanent; you can use the combined gage of cladding and backing metals in designing to meet Code requirements. Flanges and pipes can be welded on, even after vessel installation.

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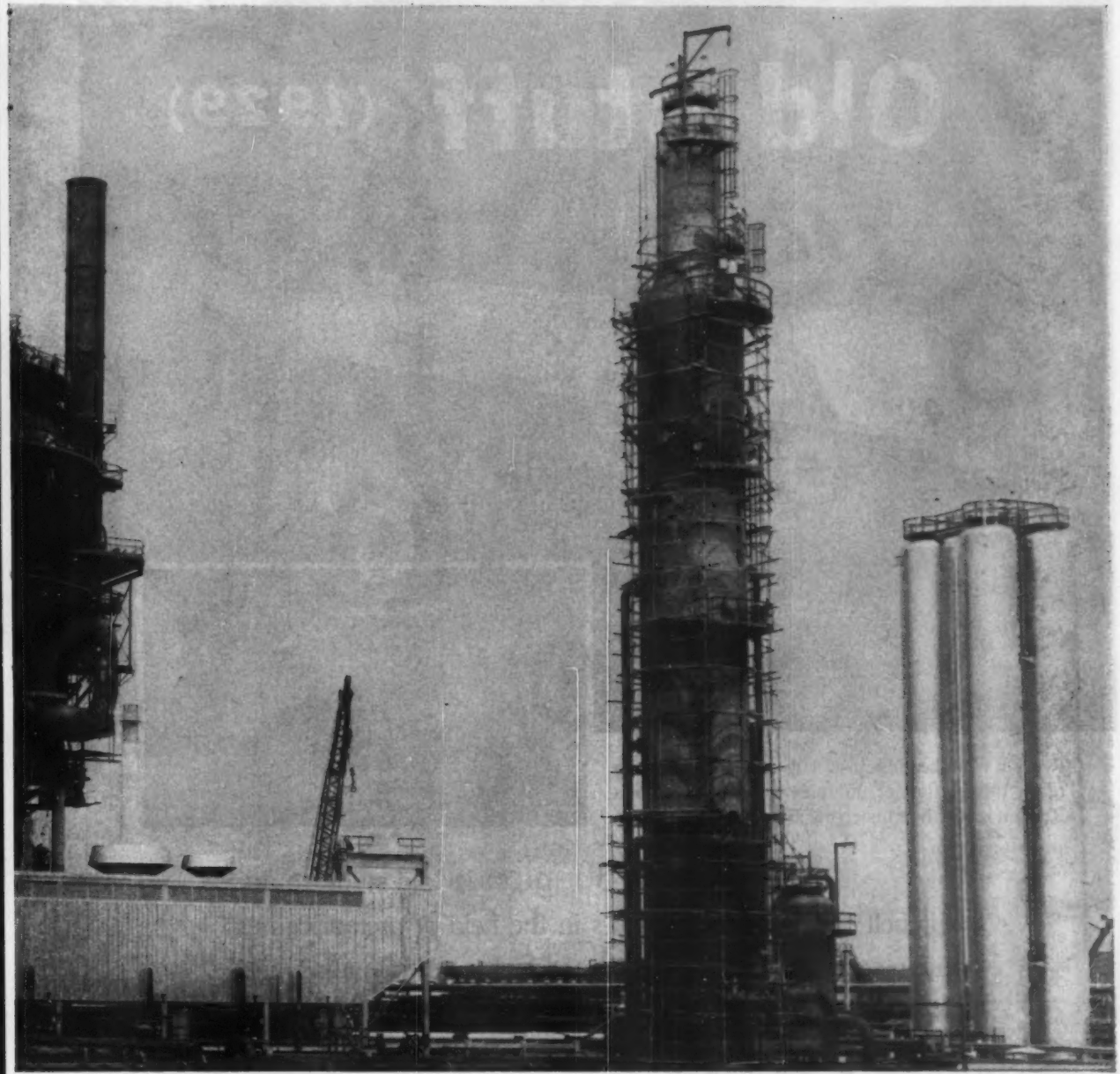


Lukens clad and alloy steels

Consult your equipment builders, or write for the new **Clad Steel Equipment** bulletin and information on alloy steels. Manager, Marketing Service, Room 897, Lukens Steel Company, Coatesville, Pa.

This is Lukens clad steel, a proven product. Not a lining, not a soldered-on surface, but a solid steel plate—one side corrosion-resistant high alloy, the other economical alloy or carbon steel permanently bonded on powerful rolling mills.

LUKENS ®

Helping industry choose steels that fit the job

Old stuff (1929)

Red hot from heating furnace to a Mitchell bending table, this section of 30″ pipe was destined to a Russian vapor line under the First Five Year Plan.

Yes, bending 30″ pipe is "old stuff" to the Mitchell organization. Pioneers in the field of prefabricating and installing high-temperature and high-pressure piping, and always abreast of every technical advance, we offer you our 58 years' specialized experience as your unqualified assurance of safety, economy and satisfaction on your next job. Ask us in.

W. K. MITCHELL & CO., INC.

Philadelphia 46, Pa.

WESTPORT JOINT
(PATENTED)

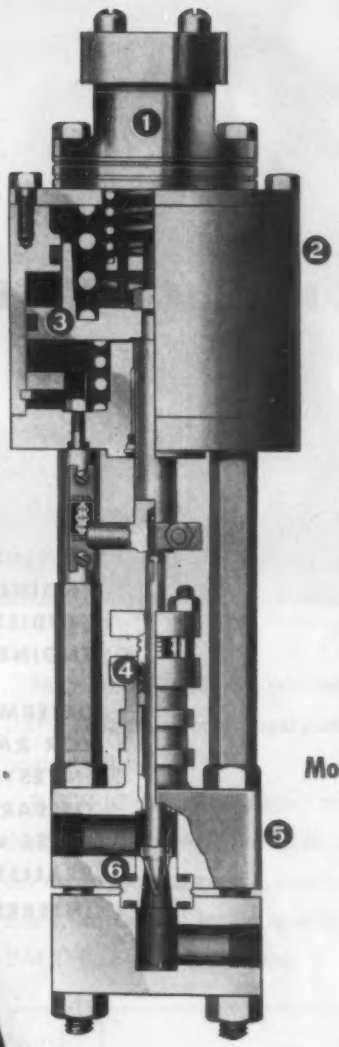
MITCHELL PIPING
SINCE 1899

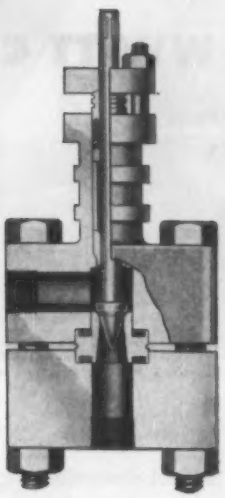
PIPING FABRICATORS AND CONTRACTORS

Split second action ...small flow control ...at 6,000 psi

New achievement by Annin in high pressure control and precise valve response for Research–Development–Process applications

Annin's new Model 9460, designed for working pressures to 6,000 psi, provides research, pilot plant and process control engineers with an extremely responsive small flow control valve suitable for low capacity systems. The operator will fully stroke in either direction in 0.75 seconds or less. New design features include: ❶ integral positioner, open-on-air-failure or close-on-air-failure action; ❷ Annin's 600 Series Domotor operator; ❸ differential area piston, eliminating need for loading regulator; ❹ universal stuffing box for –400°F to 750°F; ❺ offset globe or angle body design; ❻ valve plug stem and seat ring common to both globe and angle bodies. For reliable fluid control and flexibility of application Annin offers the *best source* for solving any small flow control problem.





Model 9461 *angle body*

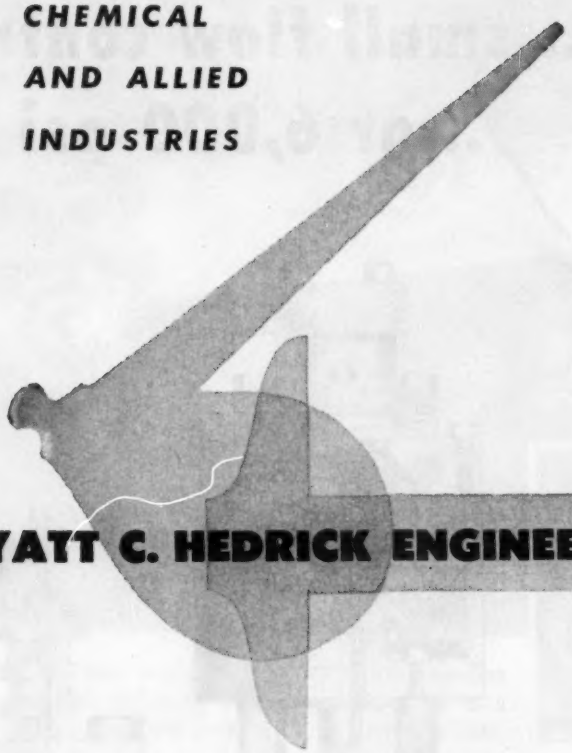
Angle bodies are available with body sections rotatable in 90°increments for piping convenience.

YOURS FOR THE ASKING–
Complete information and specifications are contained in Bulletin No. 9400. Write for your copy today.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

SERVING THE
PETROLEUM
NATURAL GAS
CHEMICAL
AND ALLIED
INDUSTRIES



WYATT C. HEDRICK ENGINEERING CORPORATION

HOUSTON, TEXAS

CONSULTATION, PROCESS AND DEVELOPMENT ENGINEERING, SURVEYS AND ECONOMIC STUDIES ARE A PART OF OUR BROAD ENGINEERING SCOPE.

DETERMINATION OF THE REQUIREMENTS FOR RAW MATERIALS, UTILITIES AND PLANT INVESTMENT PLUS AN EXTENDED FORECAST OF EARNINGS WHICH PROPERLY RELATES THESE ITEMS IS NECESSARY FOR A REALISTIC RE-EVALUATION OF YOUR INTEREST IN ANY PROCESS.

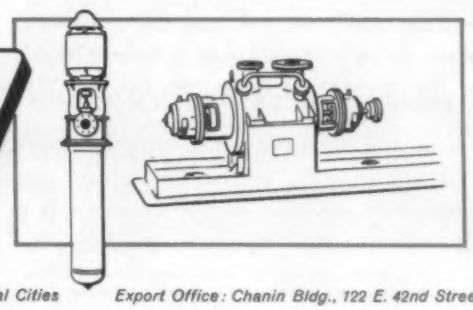
Photograph courtesy of The Lummus Company

SUNTIDE REFINING COMPANY—now only three years old—is taking long steps to strengthen its position in the refining industry. The Suntide refinery at Corpus Christi, Texas, planned for 26,300 b/d when it went on stream in 1954, already has a capacity exceeding 50,000 b/d.

New refinery units now being added will result in both higher octane and greater capacity to meet the ever-increasing demand for Suntide products.

... **PACIFIC PUMPS INC.** was selected to supply practically 100% of Suntide's centrifugal pump requirements for the original refinery.

PACIFIC was selected again to furnish virtually all of the centrifugal pumping units required in Suntide's present expansion program ... convincing evidence of Suntide's satisfaction in the quality and performance of PACIFIC centrifugal pumps.



PACIFIC®

PACIFIC PUMPS INC.
HUNTINGTON PARK, CALIFORNIA

Offices in all Principal Cities *Export Office: Chanin Bldg., 122 E. 42nd Street, New York, N. Y.*

CP-16

OPEN THIS DOOR TO GOOD CITIZENSHIP!

And gain added prestige for yourself and your industry.

Today, more than ever, good citizenship and good business go hand-in-hand!

Good citizens should be familiar with the problems of their local schools. Good businessmen should be interested in building better community relations. And here's your great opportunity—as an oilman—to do *both* at the same time! You can do it by introducing the oil industry's SCHOOL PROGRAM into your community.

Designed with the advice of educators to fit the needs of secondary schools, the SCHOOL PROGRAM tells the complete, up-to-date story about the oil industry—and the role oil plays in our American way of life. And because today's students will be your customers tomorrow, it's important that they learn the true facts about you and your business. Now *you* are going to be able to supply these facts!

Here's how you do it—

Work with your local Oil Information Committee. You will be provided with a sample package of booklets, charts and films for you to show to the Principal of the school in your town. You'll be surprised at the prestige and goodwill the SCHOOL PROGRAM will bring you and your business. Besides the important local contacts you make, teachers, students and parents will thank you for taking an active part in educating the youngsters of your community.

So start today to make friends with your customers of tomorrow. Fill out this coupon now!

American Petroleum Institute
50 W. 50th St., New York 20, N. Y.

I am interested in promoting the oil industry's SCHOOL PROGRAM in my community. Please send me the address of my nearest Oil Information Committee Field Office.

NAME_____

ADDRESS_____

CITY_____ STATE_____

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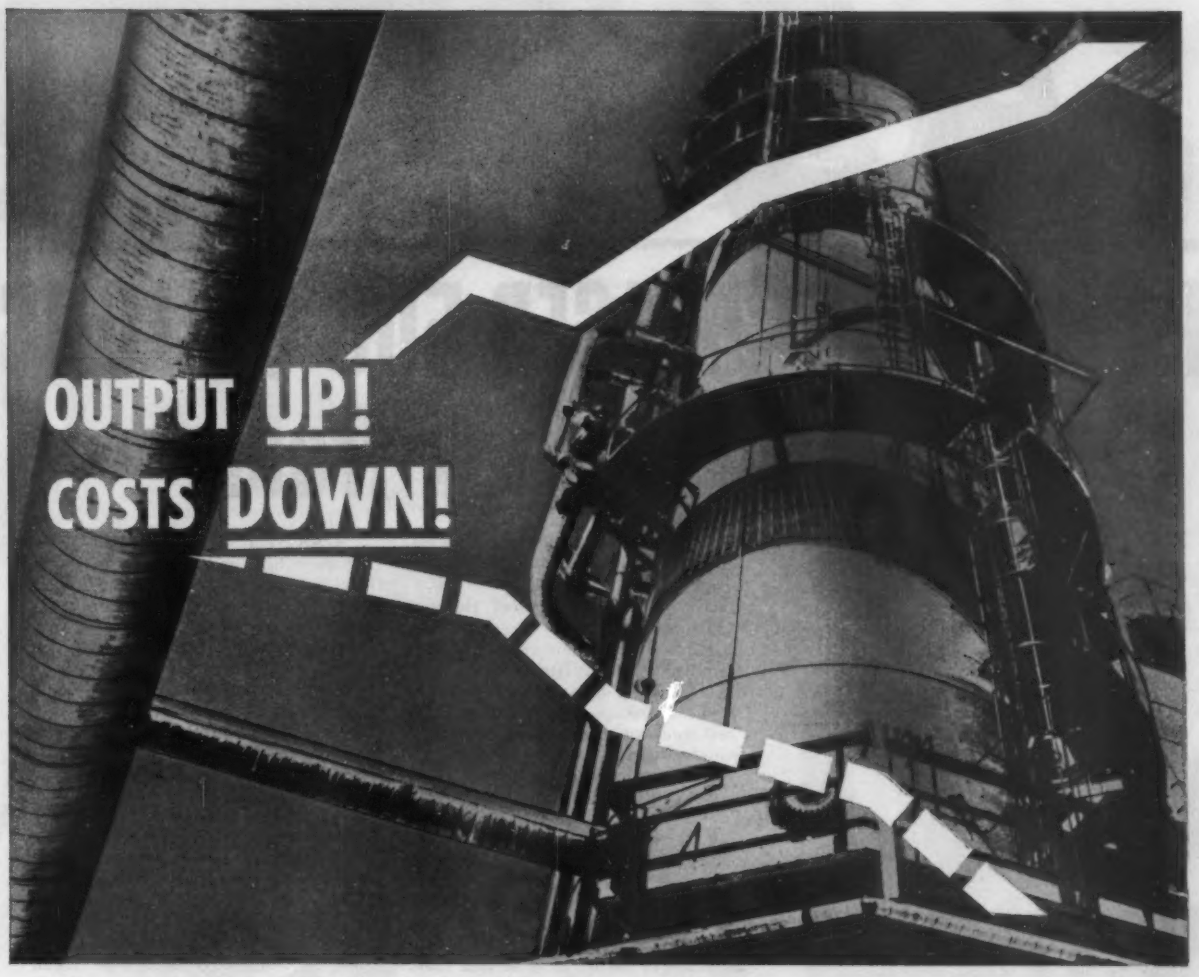

with METEX Hi-Thruput MIST ELIMINATORS

METEX Hi-Thruput Mist Eliminators, installed in process towers and vessels, effect sharp separation of liquids and gases. Quality and yield are increased. Valuable liquids are knocked out and returned. Contamination of subsequent processing is removed. Turbines and compressors are protected from damaging liquids. Where build-up of coke or solids is a consideration, on-stream service life is increased three to four times. Air pollution is reduced, too.

METEX Hi-Thruput Mist Eliminators provide virtually 100% removal efficiency, even at extreme temperatures and pressures. Pressure drop is negligible. Their outstanding performance is due to repositioning of the wires by the METEX patented Herringbone Fold . . . an exclusive development of the originators of knitted wire mesh entrainment separators. Impingement target area is increased and stagnation points reduced.

In any processing equipment or vessels where liquid entrainment is a contributing factor in design or operation, specify METEX Hi-Thruput Mist Eliminators to assure greater production, improved quality of yield and substantially reduced operating and maintenance costs.

For complete information and specifications, write today for your free copy of Bulletin No. ME-6.

6-201

METAL TEXTILE CORPORATION ROSELLE, NEW JERSEY

Metal Textile Corp. of Canada, Ltd., Hamilton, Ontario • Representatives in principal cities throughout the world

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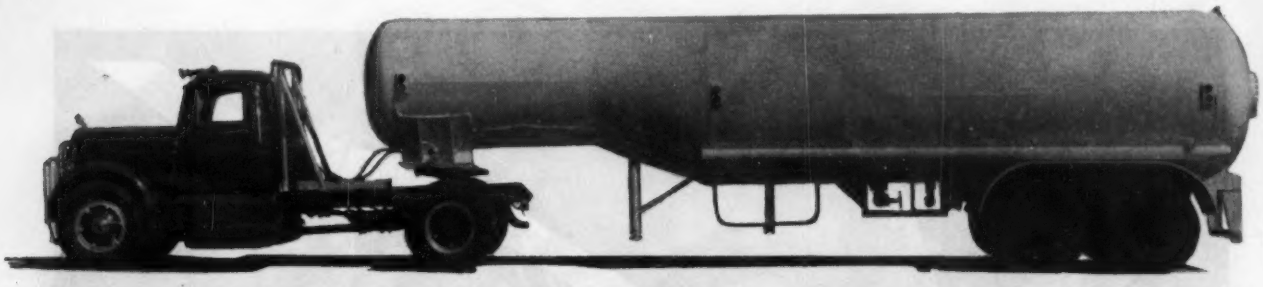


PAYLOAD INCREASED 500 GALLONS in new LPG tank truck

PRESSURE VESSEL ON WHEELS FEATURES "T-1" STEEL CONSTRUCTION

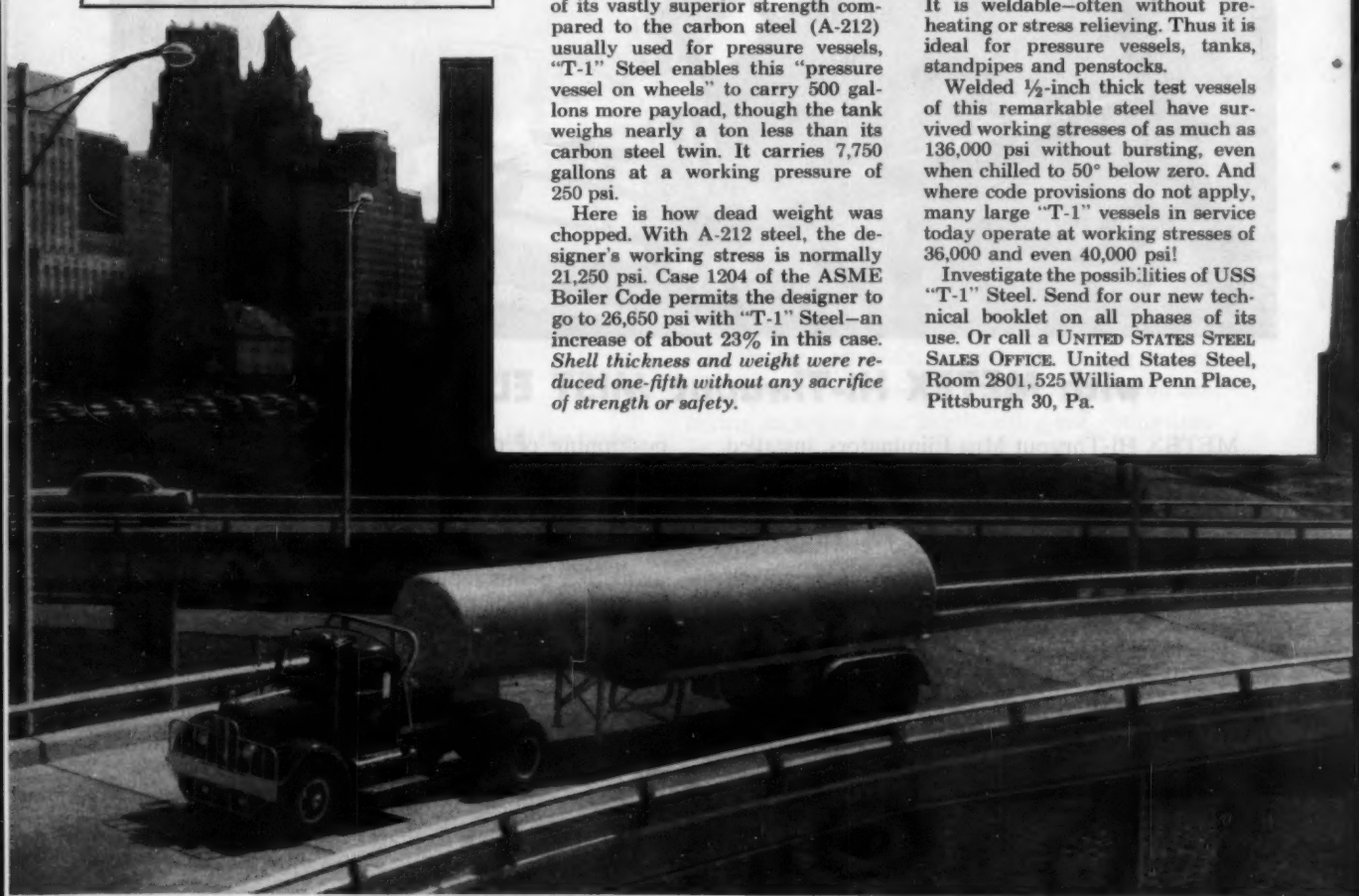
THE TANKER shown here is an important "first"—it is the *first* LPG trailer tank to be built of "T-1" Constructional Alloy Steel. Because of its vastly superior strength compared to the carbon steel (A-212) usually used for pressure vessels, "T-1" Steel enables this "pressure vessel on wheels" to carry 500 gallons more payload, though the tank weighs nearly a ton less than its carbon steel twin. It carries 7,750 gallons at a working pressure of 250 psi.

Here is how dead weight was chopped. With A-212 steel, the designer's working stress is normally 21,250 psi. Case 1204 of the ASME Boiler Code permits the designer to go to 26,650 psi with "T-1" Steel—an increase of about 23% in this case. *Shell thickness and weight were reduced one-fifth without any sacrifice of strength or safety.*

USS "T-1" Steel has, in addition to very high yield strength (90,000 psi minimum), exceptional toughness down to very low temperatures. It is weldable—often without preheating or stress relieving. Thus it is ideal for pressure vessels, tanks, standpipes and penstocks.

Welded ½-inch thick test vessels of this remarkable steel have survived working stresses of as much as 136,000 psi without bursting, even when chilled to 50° below zero. And where code provisions do not apply, many large "T-1" vessels in service today operate at working stresses of 36,000 and even 40,000 psi!

Investigate the possibilities of USS "T-1" Steel. Send for our new technical booklet on all phases of its use. Or call a UNITED STATES STEEL SALES OFFICE. United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.



UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

"USS" and "T-1" are registered trademarks.

SEE The United States Steel Hour. It's a full-hour TV program presented every other Wednesday by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL

new 15kv Loxarmor* circuits eliminate conduit, allow simple terminations

Stainless steel Loxarmor cable was recently chosen by the Petro-Tex Chemical Corporation, jointly owned by Tennessee Gas Transmission Co. and Food Machinery and Chemical Corp., for main feeder circuits in their Houston, Texas plant.

Heart of this system is Okolite insulation applied by Okonite's strip-insulating method. The advantages inherent in the Loxarmor construction add considerably to the basic advantages of the Okolite insulation.

Advantages of Loxarmor construction:

... stainless steel armor provides the ultimate resistance to corrosive atmospheres prevalent in petrochemical plants.

... reduces installation and maintenance costs because of flexibility and the elimination of rigid conduit. Open type construction permits quick, simple inspection of your electrical system.

... completely salvageable—can be reused at will or can be easily re-routed.

... standard fittings permit relatively simple terminating procedures.

Petro-Tex Chemical Corporation's use of this construction typifies the modern trend to Loxarmor. Where the maximum security of a rigid conduit is not necessary, Loxarmor is a highly acceptable alternate.

Bulletin PR-1090 provides a thorough description of Loxarmor, providing engineering information, splicing and terminating drawings and instructions, and a discussion of the various components. Loxarmor power and control cables are available with any of Okonite's strip-insulated and extruded rubber insulations or with varnished cambric and plastic dielectrics. Write for it today to The Okonite Company, Passaic, N. J.

***Okonite's trade name for interlocked S-shaped armor—available in stainless or galvanized steel, aluminum or bronze. Protective coverings can be applied over the armor for special corrosion and chemical resistance.**

4710

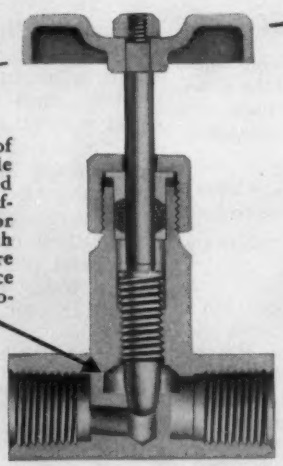
where there's electrical power ... there's **OKONITE CABLE**

MAXIMUM WORKING PRESSURE
10,000 PSI
for water, oil or gas

- Body and stem guide extra heavy bar stock fused into one piece.
- Valve stem 416 stainless steel.
- Packing special one-piece "Marpak" moulded ring.
- Bodies marked in accordance with MSS regulations.

ONE PIECE

The stem guides of conventional needle valves are screwed into bodies—this often causes leakage or blow-outs. Marsh Needle Valves are fused into one-piece by exclusive "Conoweld" process.



The Ultimate in Needle Valves

Here is one of the crowning achievements of Marsh research, design, and manufacturing skill. It is the first needle throttling and shutoff valve to combine *all* of the qualities called for today in this highly critical and ever broadening field.

It is a valve that has strength and safety to spare . . . rated for pressures up to 10,000 psi—equally efficient in the lower ranges. A product of Marsh instrument-making and valve manufacturing experience, it combines instrument-like precision with the ruggedness that distinguishes all Marsh valve specialties.

The illustrations tell the story of new thinking; new standards. Body and stem-guide are machined from extra-heavy carbon steel bar stock. Still greater strength and rigidity are achieved by fusing the stem-guide into the body. The complete fusion of guide and body is accomplished by the exclusive Marsh "Conoweld" process.

There are two big advantages to this one-piece construction: (1) It eliminates the danger of unscrewing the valve from the body when opening—a frequent cause of leakage, even dangerous blow-outs (2) It permits perfect line-up of threads and seat. As a result, Marsh valves are easier to operate even at high pressures.

The precision-machined stem is 416 stainless steel. Stem threads are fine pitch for extra strength and fine, controlled regulation. Notable advancements are special "Marpak" one-piece, non-binding longer-lasting packing; deep thread chambers, keeping inlet and outlet piping away from ports and contributing excellent flow characteristics. Entire packing nut and packing gland are electro-zinc plated, preventing corrosion and giving the valve a handsome, plated exterior. The rugged malleable handle is finished in heavy baked enamel.

The new needle valve line includes globe and angle patterns with double female connections in sizes ⅛", ¼", ⅜", ½", ¾" and 1". Also globe and angle valves with male inlet and female outlet in sizes ¼" and ½". *Complete stock carried at our Skokie, Illinois factory and also at our branch plant in Houston, Texas.*

Write today for catalog giving complete details.

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corporation*
Dept. R, Skokie, Ill. • **Marsh Instrument & Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta** • **Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas**

MARSH

"THE STANDARD OF ACCURACY"

Sherman Equipment "On-the-Job" While Other Machines Stand Idle

The Contractor: The Webster Company, St. Paul, Minn.

The Job: Install an automatic lawn sprinkler system for a new school.

The Problem: Heavy rains which threatened to prevent completion of the job on schedule. Trenching machines clogged up and track-type dozers tore up the rough graded area.

The Solution: A lightweight Sherman back-hoe for the trenching with the ability to push itself along the ground with its dipstick. For backfilling and backgrading, the Sherman AJ 25 Loader on the dependable Fordson Major Tractor is used. Because of its mounting and leverage design, it transfers more weight to the big driving wheels of the tractor with resulting traction advantage. Easy steering is assured by the Sherman Power Steering unit.

Actually, the Webster Company has found its Sherman equipment profitable even on a rental basis where operators can be expected to give a rig all the abuse it will stand. Rugged, heavy-duty construction is a prominent feature of all Sherman Power Diggers, Loaders, Fork Lifts and other equipment. See them in action soon at your local Ford Tractor Dealer or write for Bulletin No. 3360.

*Manufactured for Sherman Products, Inc., by Johnson Hydraulic Equipment Company, Minneapolis, Minnesota

†Designed, Engineered and Manufactured jointly by Sherman Products, Inc., Royal Oak, Michigan. Wain-Roy Corporation, Hubbardston, Mass.

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SHERMAN MAJOR DIGGER-LOADER COMBINATION performs a great many different jobs for the city of Dearborn, Michigan. The unit is used to dig water main taps and sewer sections, to install fire hydrants, to load and backfill and to do many miscellaneous jobs.

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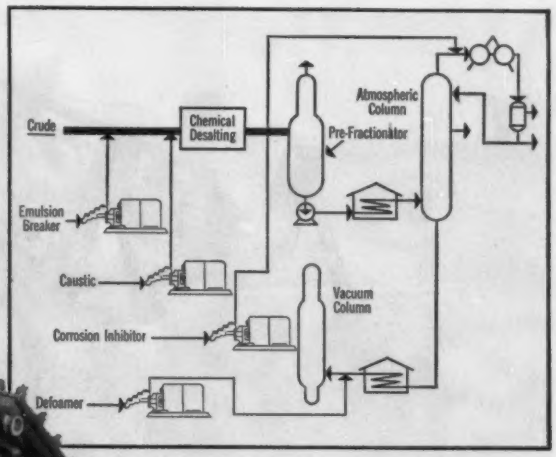
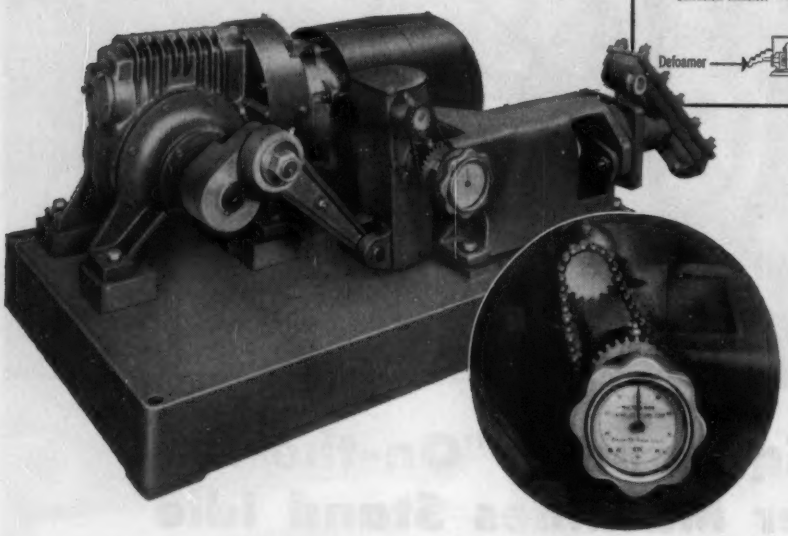
POWER DIGGERS† • FRONT END LOADERS* • FORK LIFTS

Sherman SP Products



Controlled Volume Pump with dial adjustment which changes stroke length while pump is operating. Typical applications shown (right) include the metering of corrosion inhibitors, defoamers, and desalting chemicals.



Efficient chemical treatment safeguards quality of your products

Controlled Volume Pumps accurately meter acids, caustics, inhibitors and additives against a head

Spot these positive-displacement metering pumps throughout your process, to handle oxidation and corrosion inhibitors . . . octane appreciators . . . sulfuric acid or water treating chemicals . . . emulsion breakers . . . defoamers. *Wherever* you use Milton Roy Controlled Volume Pumps, you'll enjoy savings in chemical costs, while safeguarding product quality.

What's more, the simplicity and dependability of these pumps reduce installation cost, minimize shutdown time and maintenance.

Write for detailed information on Controlled Volume Pumps as they relate to your particular application.

Milton Roy Company, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pennsylvania.

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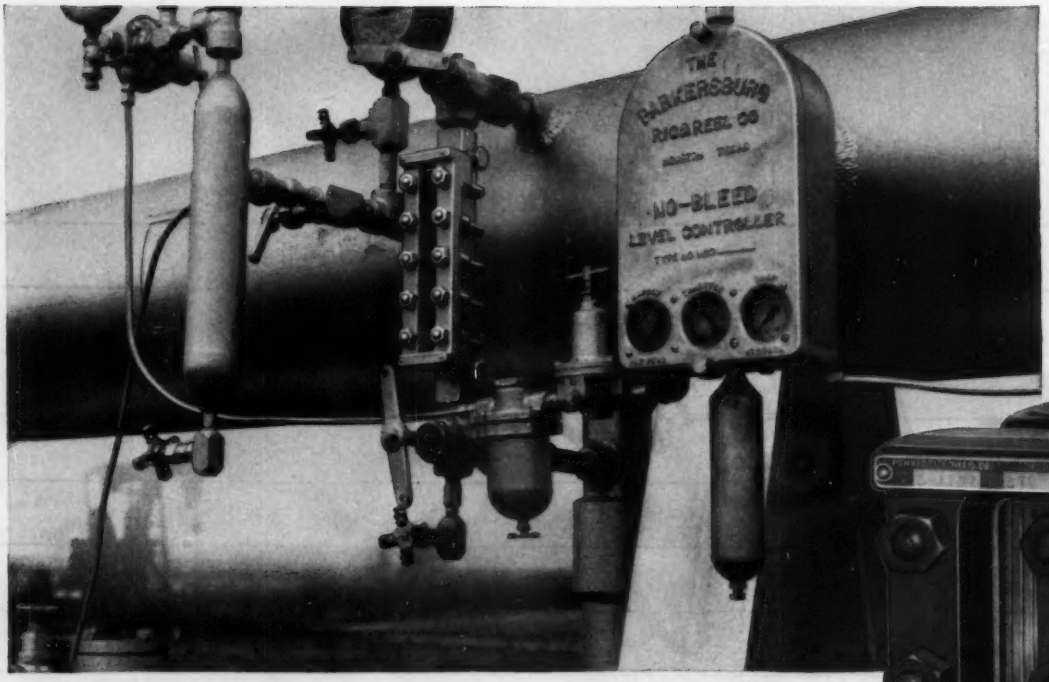

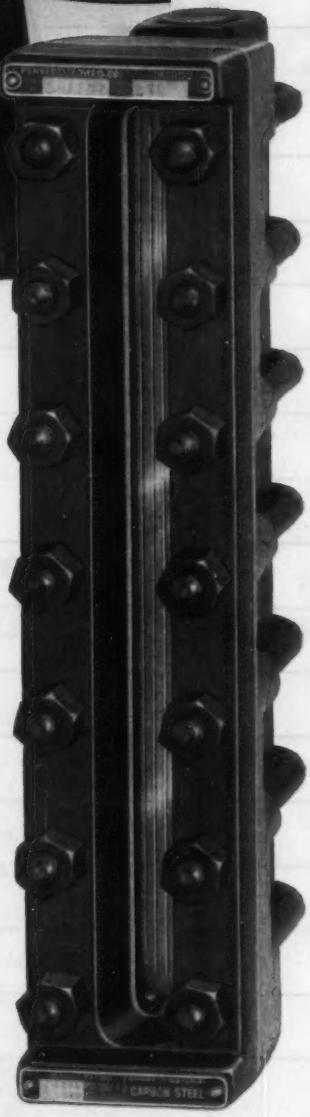

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say Parkersburg Engineers. "PENBERTHY gages are preferred as accessories by the men who specify and use our pressure vessels. They are established as a quality product in the minds of most of our customers. That's good enough for us!"

This PARKERSBURG single-stage horizontal separator is used to separate oil well fluids into liquids and gas. It is only one in the famous line of PARKERSBURG separators equipped with PENBERTHY gages.

To closely regulate interface surfaces, a special NO-BLEED level controller (above) assures quick dump valve opening and controls the amount of oil discharged.

For DOUBLE PROTECTION, a PENBERTHY liquid-level gage provides instant visual proof that interface levels are properly maintained.

Similar applications are found throughout the refinery and petro-chemical industries where accurate liquid-level readings are vitally important.

To provide the kind of service these industries require, PENBERTHY gages are designed and tested for rugged strength and accurate performance. The exclusive "raised face" glass reduces internal stresses assuring longer glass-life and a minimum of maintenance.

PENBERTHY gages may be purchased through supply stores in your area. For detailed information on complete PENBERTHY line, write for free copy of Catalog #36.

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Division of Buffalo-Eclipse Corporation

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***There's Certain Satisfaction in* PRODUCTS BY PENBERTHY**

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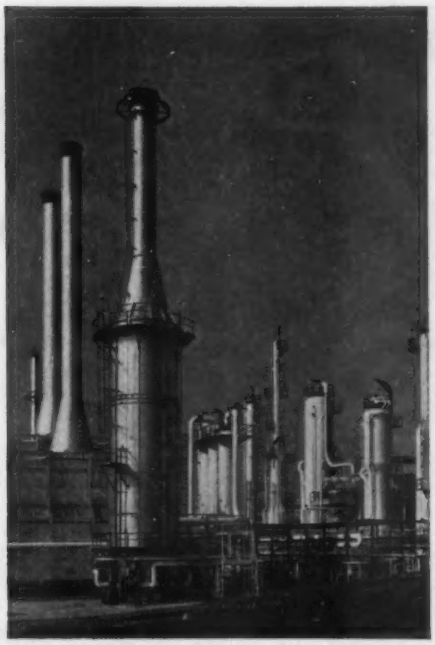
- CYCLING JET PUMPS
- ELECTRIC SUMP PUMPS
- LIQUID LEVEL GAGES
- GAGE VALVES



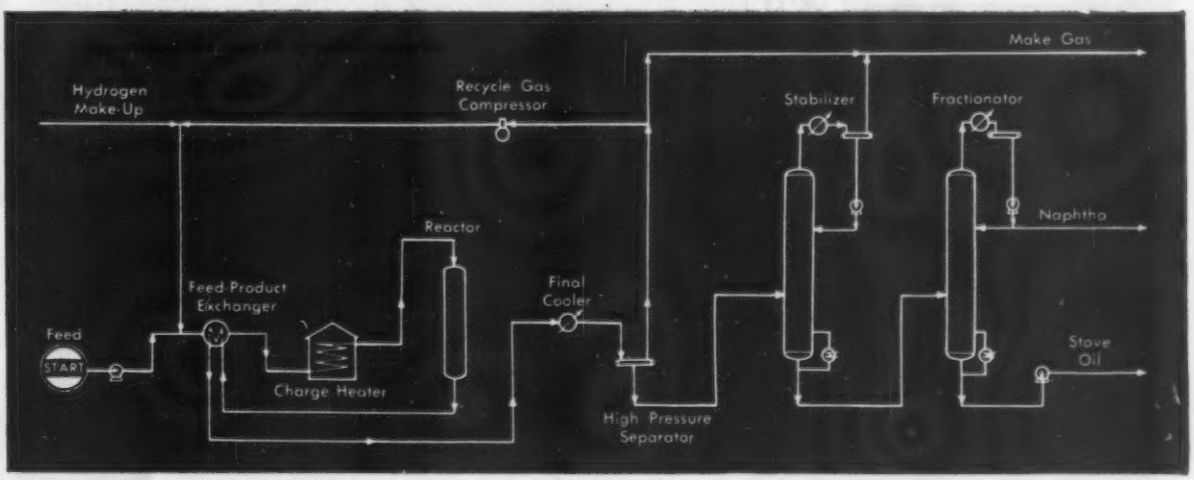
Unifining Unit, Union Oil Company of California refinery, Oleum, California uses Harshaw Cobalt Molybdate Catalyst.

For Hydrodesulfurization

HARSHAW COBALT MOLYBDATE CATALYST

★ **223 regeneration cycles without loss in activity**—a typical performance given by Harshaw Cobalt Molybdate Catalyst, accomplished while treating one of the most difficult charge stocks.

★ **Recording less than 1.0¢/bbl. accumulated costs**—with no indicated loss of activity, Harshaw CO-MO has been full scale tested the longest of any hydrodesulfurization catalyst.



Since you know the critical ingredient of any catalytic hydrogenation reaction is the *catalyst*, the above facts should prompt you to acquire complete details on this premium commodity in the field of catalytic hydrogenation. We shall be happy to point out the many specific advantages that come with using Harshaw Cobalt Molybdate Catalyst and discuss any specific application you may be considering.

Feel free to contact your nearest Harshaw office

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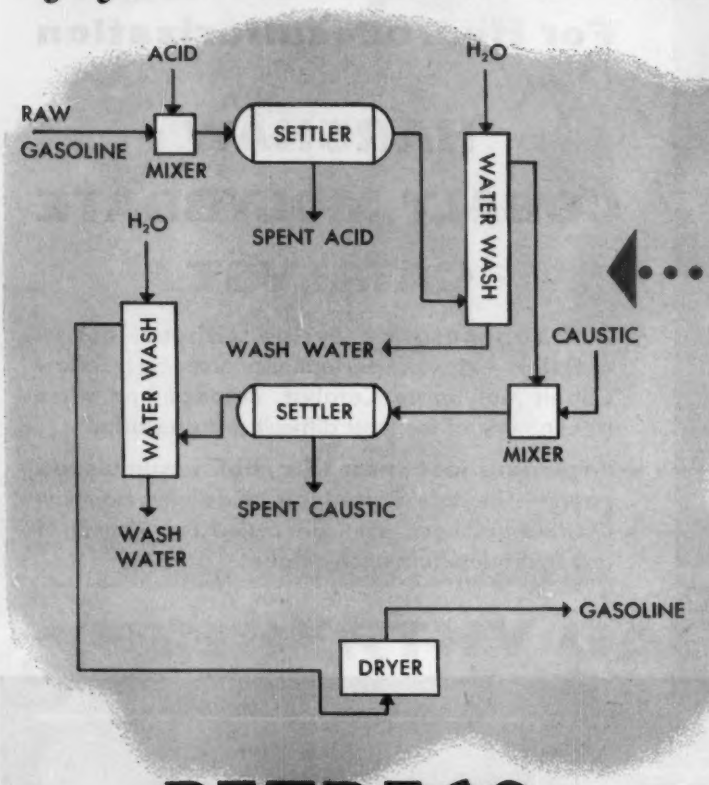

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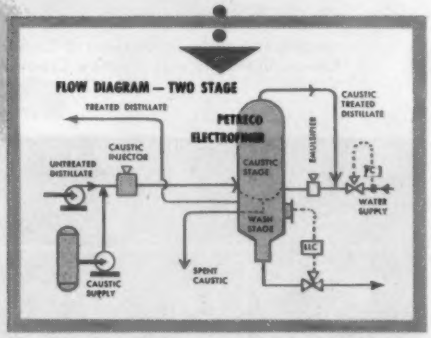

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saves space, pumps, piping and vessels

Electrofining, as pioneered by Petreco, is a continuous, precision controlled operation that is superior in every way: *easier*, because it affords efficient, once-through treatment; *cheaper*, because it requires but one vessel as compared with the 3 or 4 in conventional systems, as well as proportionately less piping, pumps or ground area; *faster*, because it delivers sharp, clean separation of hydrocarbon and caustic-wash phases, cuts settling time from days to hours. The result is a *finer finished product*, ready for market.

Write for FREE COPY *on* "PETRECO ELECTROFINING—*A New Concept in Light Oil Refining.*"

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A DIVISION OF PETROLITE CORPORATION

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DT-57-1

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Building is a practical art. Its application takes brains, experience, vision and a disciplined devotion to the most exacting detail of the specifications and the time schedule. We've built an organization here at Procon that practices this art in this realistic way.

This Procon service is offered to the oil refining, chemical and petrochemical industries, anywhere in the world. New plant construction, expansion or modernization, whatever the requirement, Procon will do it right, and on time.

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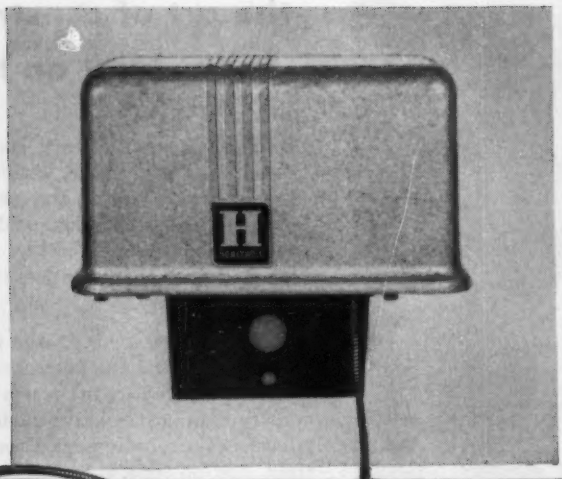
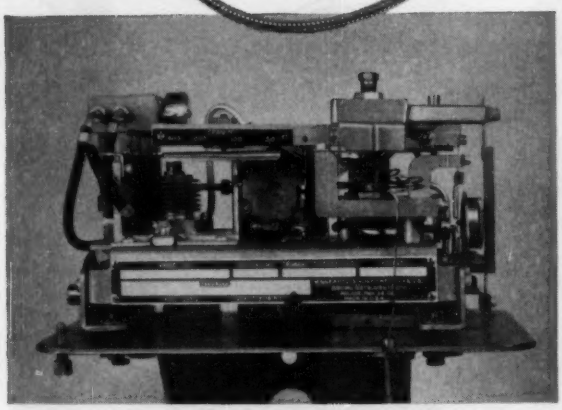


You can mount the transmitter at the point of measurement, either indoors or out. A sturdy, weatherproof aluminum cover protects all working parts and adjustments.

Interior view of the transmitter shows the accessibility of all parts. Span and zero adjustments are easy to make, and no changes of parts are required.



only the TEL-O-SET transmitter

gives you full rangeability without changing parts

THE *Tel-O-Set* transmitter offers complete versatility. This highly accurate force-balance instrument measures temperature, gage pressure or absolute pressure, and transmits a proportionate output signal to a receiver or controller. It requires only one thermal system and one pressure system for all ranges, and changeover from temperature to pressure measurement is extremely simple.

You can adjust the span to any values between 20 and 150 psi, or 50 F and 400 F. And you can shift the span to cover any part of the overall transmitter range . . . from 40 to 600 psi, or from —375 to 1000 F . . . *without changing parts.*

The *Tel-O-Set* transmitter is unmatched in performance. It's just as accurate at small spans of 20 psi and 50 F as at wide spans of 150 psi and 400 F. It responds swiftly to changes in temperature or pressure to give you control within close tolerances. It's effectively compensated for ambient temperature and pressure, and fully protected against the effects of vibration.

Get complete details on *Tel-O-Set* transmitters . . . and related *Tel-O-Set* miniature indicators, recorders and controllers . . . from your nearby Honeywell sales engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA: Write for Specification S1003-1.**

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GC Allied Chemical

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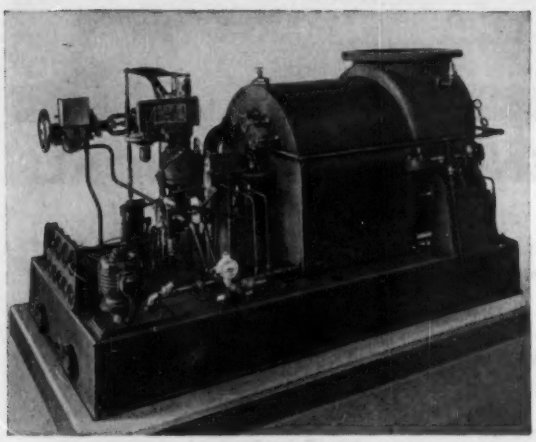
Terry high-speed, high-horsepower turbine on continuous compressor-drive service at National Petro-Chemicals Corporation.

Hedrich-Blessing photo

At National Petro-Chemicals Corporation . . .

Terry high-speed compressor-drive turbines provide continuous 'round-the-clock service



One of the two 5400 hp., 7486 rpm turbines built for the Tuscola plant of National Petro-Chemicals Corporation.

In the fall of 1953, five Terry multistage turbines were placed on day-and-night duty at the Tuscola, Illinois, Plant of National Petro-Chemicals Corporation. They drive high-speed compressors used to compress hydrocarbon gases in the production of ethylene.

The *excellent performance of these initial units later resulted in the installation of two more Terry machines.* These were placed in service some two years later.

In all, the seven turbines total more than 30,000 hp. They range in capacity from 3300 to 5400 hp., and in speed from 7500 to 9700 rpm.

The National Petro-Chemicals installation, and the thousands of other units serving in refineries and chemical plants throughout the world, are testimony to the low maintenance and consistent reliability of Terry turbines. Put Terry to work for you. Write for further information.

THE TERRY STEAM TURBINE CO.

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industrial lighting fixtures

EXPLOSION-PROOF
LE Series (Class I, Groups C and D)
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Choice of body and reflector styles

EXPLOSION-PROOF Floodlights
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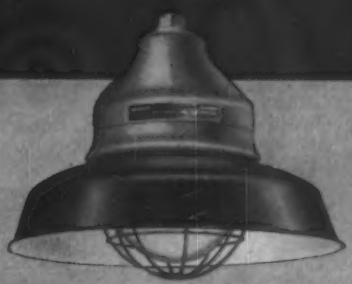

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DE Series (Class II, Groups E, F and G and Class III)
60 to 200 Watts
Choice of body and reflector styles

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Choice of body and reflector styles

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5086

HIGHEST STRENGTH ALUMINUM FOR UNFIRED PRESSURE VESSEL FABRICATION

Kaiser Aluminum now offers you alloy 5086 . . . the highest strength aluminum alloy available for the fabrication of unfired pressure vessels.

Non-heat-treatable 5086 is designed specifically for welded structures requiring maximum joint strength and efficiency, plus light weight and corrosion resistance.

And, with high-strength 5086 you can take advantage of inert-gas, shielded-arc welding methods for faster welds and pressure tight joints.

Development of 5086 by Kaiser Aluminum makes possible many new applications of light weight, durable aluminum for the chemical and petroleum industries. Find out now how this versatile alloy can serve you.

For complete information, call the Kaiser Aluminum sales office listed in your phone directory. Process Industries Department, Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

PHYSICAL CHARACTERISTICS OF ALLOY 5086

Typical mechanical properties in various tempers

	Temper			
	"0"	H32	H34	H112
Tensile strength (psi)	38,000	42,000	47,000	39,000
Yield strength (psi)	17,000	30,000	37,000	19,000
Elongation (% in 2")	22	12	10	14

Allowable design stress values

	For metal temperature not exceeding deg. F.	
Condition (temper)	100°	150°
Annealed	8700 psi	8700 psi
H112	8700	8700
H32	10,000	9900
H34	11,000	10,800

Allowable stress values for welded construction compared with other alloys

Alloy Designation		For metal temperature not exceeding 150° F. (annealed condition)
AA	ASTM	
1160	996A	1650 psi
1100	990A	2350
3003	M1A	3150
3004	MG11A	5650
5050	G1A	4000
5052	GR20A	6250
5154	GR40A	7350
5086	GM40A	8700

Nominal composition

4.0% magnesium
0.45% manganese
0.10% chromium

Typical weld strengths (specimens tested across the weld)

37,000 psi tensile strength
18,000 psi yield strength
13% elongation

Kaiser aluminum 5086 is available in flat and coiled sheet, plate and extrusions.

Kaiser Aluminum

materials for the process industries

See "THE KAISER ALUMINUM HOUR." Alternate Tuesdays, NBC Network. Consult your local TV listing.

TAKE A TIP FROM

ON HANDLING TOUGH CORROSIVES!

USE **CHIKSAN**

LOADING ARMS

To maintain smooth production schedules, Eastman Kodak brings corrosive solvents and acids to its Rochester plant via truck from nearby tank farm storage. Corrosive action, however, was destroying loading hoses after comparatively short periods of use. To overcome this costly problem Kodak replaced its hoses with Chiksan Loading Arms. That was 10 years ago. Today, there are over 40 Chiksan Loading Arms in service at Kodak Park and not one record of product fatigue to date.

Whatever your fluid handling requirements, be it corrosive or other, insist on Chiksan Loading Arms—the time proven answer where the accent is on service, safety and speed.

There's a Chiksan Catalog waiting for you. Send for it today.

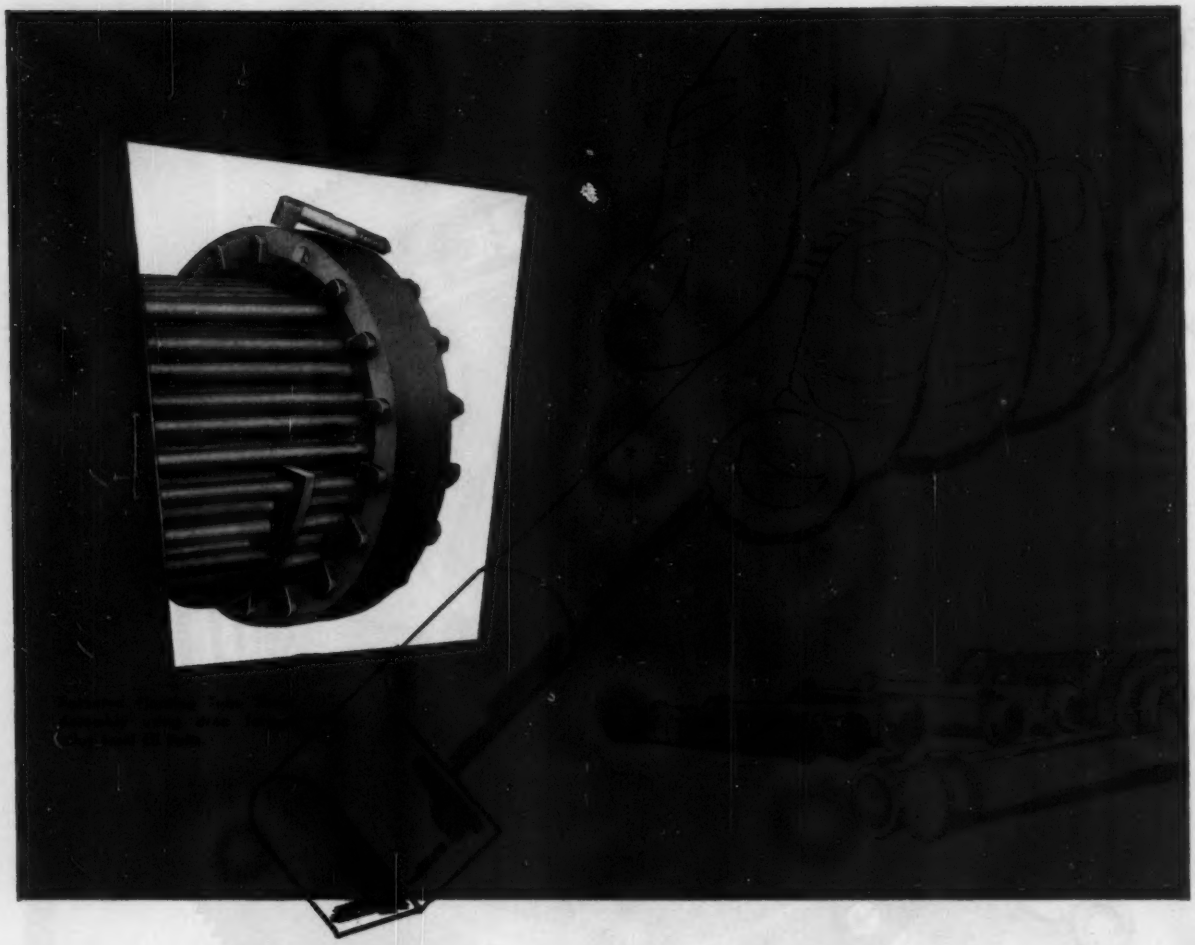
FOR CATALOG, WRITE DEPARTMENT 53

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

fmc **CHIKSAN**

CHIKSAN COMPANY—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries: Chiksan Export Company • Chiksan of Canada, Ltd.



This Ell Bolt is the Key to leak control

The patented Ell Bolt construction employed on Vogt floating head heat exchangers is the answer to re-assembly without distortion or leak development.

Cover may be removed by simply loosening the Ell Bolt nuts and disengaging the Ell Bolt heads from the "lock notches." No misplacing of Ell Bolts can result — and tightening is easy and positive — absolutely leak proof. Send for Bulletin HE-6. Address Dept. 24A-XPR.

Vogt

HENRY VOGT MACHINE CO., P. O. BOX 1918, LOUISVILLE 1, KY.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Philadelphia, St. Louis, Charleston, W. Va., Cincinnati

OTHER VOGT PRODUCTS

Drop Forged Steel Valves, Fittings and Flanges in a complete range of sizes • Petroleum Refinery and Chemical Plant Equipment • Steam Generators • Heat Exchangers • Ice Making and Refrigerating Equipment.

HEAT TRANSFER EQUIPMENT

THE LITTLE VALVES WITH THE BIG JOB

The Rockwell-Nordstrom valves on the emergency shut-off manifold above have a really big job. On their absolute dependability rests millions of dollars of capital investment.

Why do you so often see Rockwell-Nordstrom lubricated plug valves in the really vital spots? The answer: users know they provide *both* essentials of a truly dependable valve. They won't stick or gall—pressurized lubricant readies the plug for *instant, quarter-turn operation.* And, equally important, they assure *positive shut-off.*

These same important advantages—instant operation and positive shut-off—also make Rockwell-Nordstrom valves your best investment for practically every flow control need. And they cost no more to buy, often less, than ordinary valves. For complete details, call your supplier or write Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee:* Peacock Brothers Limited.

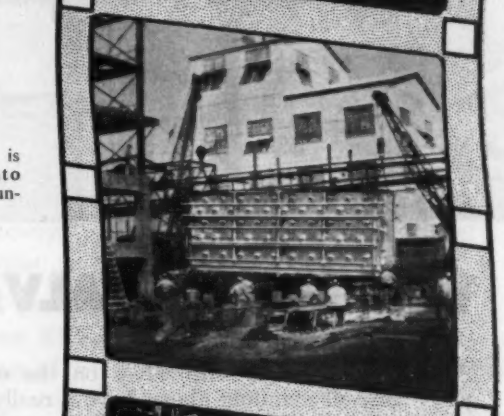
ROCKWELL-Nordstrom VALVES

Lubricant Sealed For Positive Shut-off

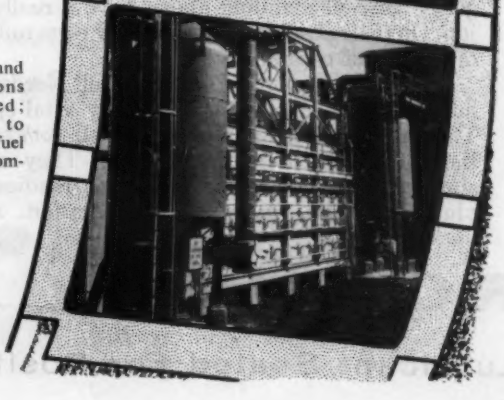
Selas prefabrication saves time and money at job-site

After final inspection, the completed Selas Gradiation Heater is securely anchored on flatcar for shipment. Stack and convection sections are in adjoining car.

Upon arrival at job-site, cranes allow flatcar to be slipped out, Lo Boy slipped in.



The heater is lowered onto prepared foundations.



Convection and stack sections are installed; connection to process and fuel gas piping completes job.

SELAS prefabrication means much more than the accepted definition of prefabrication: *it is shop-assembly*. In capacities as large as 45 million Btu/hr coil duty, Selas Gradiation® Heaters are *complete* when they are shipped out: burners, brickwork, arch tiles are in place; manifold piping is attached and intact, complete with flanged connections; stacks and ducts completely insulated. Heating coils can be shipped installed or delivered to job-site, pre-assembled on tube supports, as desired.

In terms of field effort, Selas *shop-assembly* means complete erection of sub-assemblies on job-site foundations in less than eight hours!

Whatever your needs—*shop-assembly* or field-assembly—Selas Gradiation Heaters will give you longer "on-stream" periods, high conversions and selectivity, Zone Control of heat input, uniform heat distribution on the entire tube surface which extends tube life. Send for Bulletin 143 "Gradiation Heating for Petroleum and Chemical Processing."

SELAS
CORPORATION OF AMERICA

DRESHER, PENNSYLVANIA

HEAT AND FLUID PROCESSING ENGINEERS
DEVELOPMENT . . . DESIGN . . . CONSTRUCTION

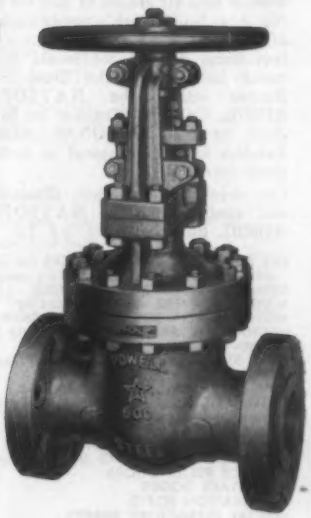
...more quality proved POWELL VALVES

FIG. 375—Bronze "White Star" Gate Valve for 200 pounds W.S.P.

FIG. 2467—Stainless steel O.S. & Y. Gate Valve for 300 pounds W.P.

FIG. 6003—600-pound Steel O.S. & Y. Gate Valve

FIG. 3061—300-pound Steel Swing Check Valve



for dependable flow control

Consult your Powell Valve distributor for full facts about quality proved bronze, iron, steel and corrosion-resistant valves. For every flow control problem—there is a Powell Valve to solve it.

THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR

For more data on advertised products, use Readers' Service Cards, last page.

NATIONAL AIROIL

Oil Burners

OF THE STEAM AND MECHANICAL TYPES NOW COMBINED INTO

Dual Stage BURNERS

Now, at last, the inherent advantages of *both* systems of fuel oil atomization are *profitably* yours . . . within the one, new NATIONAL AIROIL Dual Stage Burner.

45 years of combustion equipment design and manufacture are in back of the Dual Stage Oil Burner . . . and, it has been thoroughly tested and proved in the field for firing: Petroleum Processing Heaters; Rotary Kilns; H.R.T., Scotch Marine and Water Tube Boilers; etc.

Available in three sizes, the NATIONAL AIROIL Dual Stage Burner fires all grades of fuel oil from No. 2 to No. 6, with a ready capacity of 80 to 300 g.p.h. Further, for a perfect flame pattern, we would recommend using with the Dual Stage Burner either the NATIONAL AIROIL Universal Register for forced draft or the NATIONAL AIROIL Tandem Unit for natural or induced draft furnaces.

Get detailed description, illustration, and specifications in NATIONAL AIROIL Bulletin 25.

OIL BURNERS and GAS BURNERS for industrial power, process and heating purposes
STEAM ATOMIZING OIL BURNERS
SLUDGE BURNERS, Steam Atomizing
MOTOR-DRIVEN ROTARY OIL BURNER
MECHANICAL PRESSURE ATOMIZING OIL BURNERS
DUAL STAGE, combining Steam and Mechanical Atomization
LOW AIR PRESSURE OIL BURNERS
AUTOMATIC OIL BURNERS, for small process furnaces and heating plants
GAS BURNERS
COMBINATION GAS & OIL BURNERS
FUEL OIL PUMPING AND HEATING UNITS
FURNACE RELIEF DOORS
AIR INTAKE DOORS
OBSERVATION PORTS
SPECIAL REFRACTORY SHAPES

Established 1912 — Incorporated 1917

NATIONAL AIROIL BURNER COMPANY, INC.

1254 E. Sedgley Ave., Philadelphia 34, Pa.
S. W. Division: 2512 So. Blvd., Houston 6, Texas

The Mail Box . . .

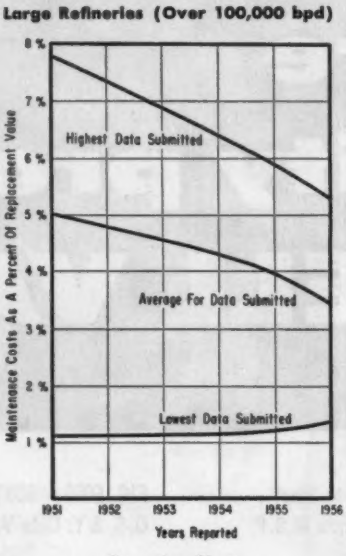
From the Editor

To Our Readers:

There have been several inquiries concerning the basis of our Maintenance Cost Survey which appeared on Page 174 in the January, 1957 issue of PETROLEUM REFINER.

The following is a description of the method used to obtain the data for the survey:

The basis for the maintenance costs



in the survey is the actual cost of repair labor and repair parts, in any given year. These maintenance costs are exclusive of direct operating labor, other payroll labor, power, lubricants, chemicals, overhead, depreciation, etc.

The basis for determining replacement value, for the years 1951 through 1956, is to multiply the cost of the plant in year completed by a factor which relates that cost to each of the years 1951 through 1956.

Factors which were used to determine replacement values show in the following table, which is based on Stevens Valuation Quarterly.

Year Facility Was Completed	1956	REPLACEMENT FACTOR 1955	1954	1953	1952	1951
1938.....	2.409	2.445	2.433	2.376	2.108	2.075
1940.....	2.433	2.276	2.108	2.075	2.007	1.989
1943.....	2.075	2.007	1.989	1.650	1.364	1.247
1944.....	2.007	1.989	1.650	1.247	1.247	1.209
1945.....	1.989	1.650	1.364	1.247	1.247	1.209

The U. S. Department of the Interior publishes a similar table that may be used to determine replacement values. The Editor

Used and Used

To The Editor:

Thank you so much for the copies of "Thermal Stresses in Piping Systems" by William E. Wilbur (PETROLEUM REFINER March, April, May, 1953). I am sorry that you were put to so much trouble. Two of us in the office use this article as our flexibility design standard and we certainly appreciate having enough copies to go around.

E. H. Boullioun, Jr.
Project Engineer
Cosden Petroleum Corp.,
Big Spring, Texas

California Posey

To The Editor:

May I take the opportunity to compliment you on the fine manner in which you have printed (and reprinted) my article, "Management's 'Forgotten Men.'" Not only was the material exceedingly well presented, from the standpoint of editorial arrangement and layout, but I have received a number of compliments from friends and others throughout various parts of the country. It has, indeed, been a pleasure to work with you in this connection.

J. M. Trickett,
Coordinator, Organization and Management Delevolpment
Food Machinery and Chemical Corp.
San Jose, Calif.

Discovery!

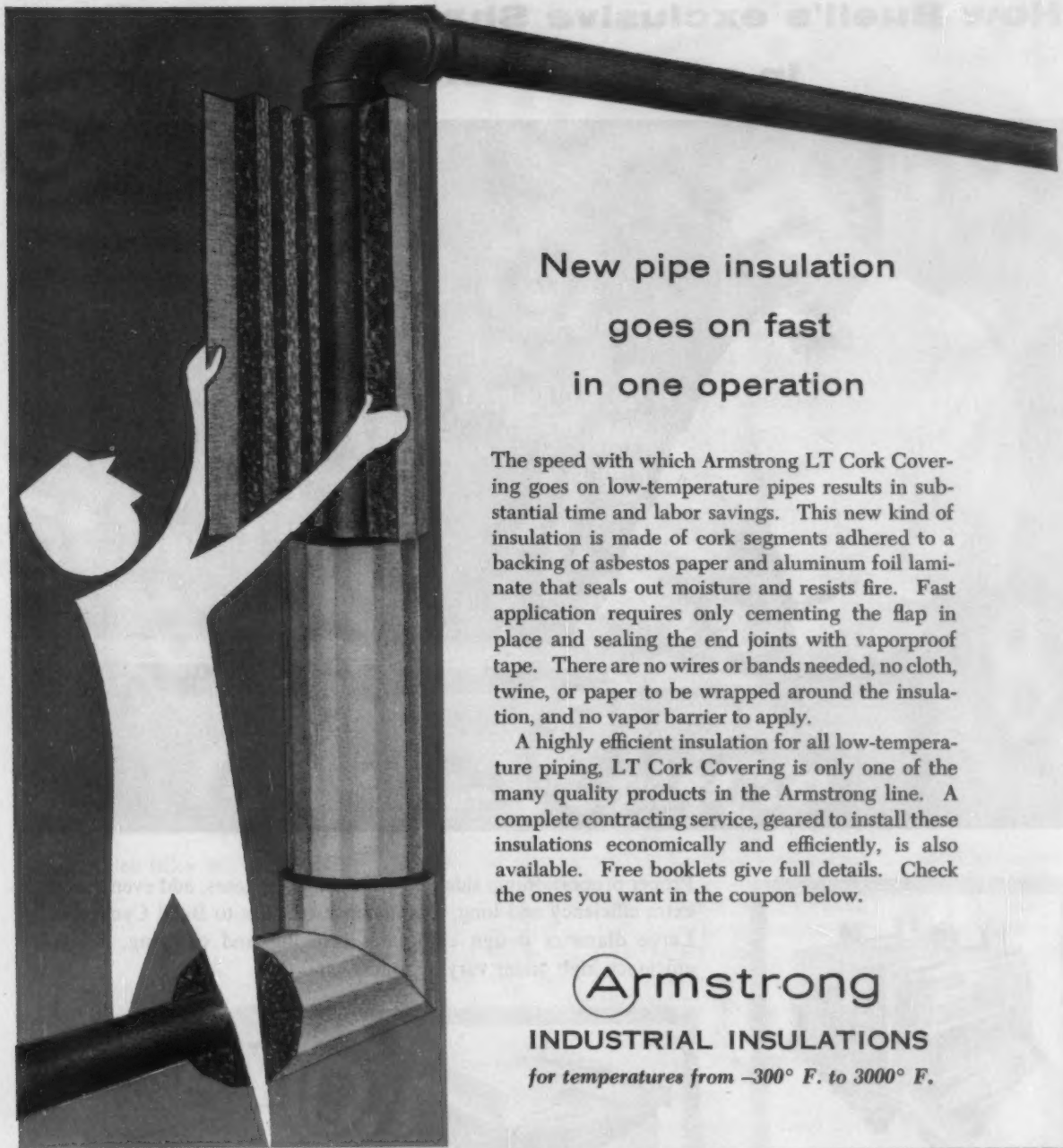
To The Editor:

I was greatly pleased to find the index of 1956 bound properly again in the December issue.

It was only a couple of weeks ago that I finally found the neat little box on the lower left hand corner of page 248 of the December 1955 issue telling how the 1955 index might be obtained. I hope that one is still available.

Robert A. Baxter
Professor of Chemistry
Colorado School of Mines
Golden, Colo.

For more data on advertised products, use Readers' Service Cards, last page.



New pipe insulation goes on fast in one operation

The speed with which Armstrong LT Cork Covering goes on low-temperature pipes results in substantial time and labor savings. This new kind of insulation is made of cork segments adhered to a backing of asbestos paper and aluminum foil laminate that seals out moisture and resists fire. Fast application requires only cementing the flap in place and sealing the end joints with vaporproof tape. There are no wires or bands needed, no cloth, twine, or paper to be wrapped around the insulation, and no vapor barrier to apply.

A highly efficient insulation for all low-temperature piping, LT Cork Covering is only one of the many quality products in the Armstrong line. A complete contracting service, geared to install these insulations economically and efficiently, is also available. Free booklets give full details. Check the ones you want in the coupon below.

Armstrong

INDUSTRIAL INSULATIONS

for temperatures from –300° F. to 3000° F.

☐ Armstrong LT Cork Covering, for all low-temperature lines

☐ Armstrong Corkboard, for all low-temperature rooms

† Trade-Mark

☐ Armstrong Armaglas* Insulations, for low-temperature rooms

☐ Armstrong Armalite†, a new, lightweight insulation for cold rooms

Armstrong Cork Company
2003 Ream Ave.
Lancaster, Penna.

Please send me the free booklets checked. ☐

Please have an Armstrong representative call. ☐

Name .....

Position .....

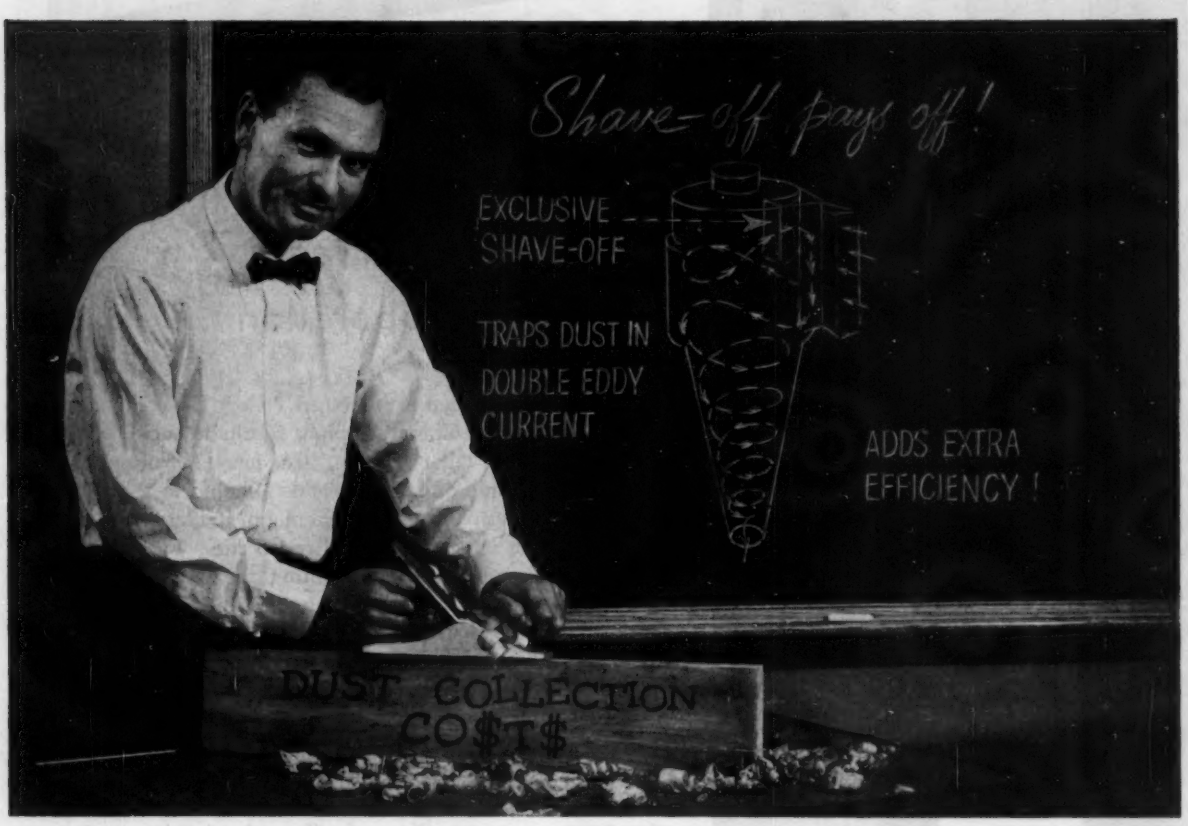
Company .....

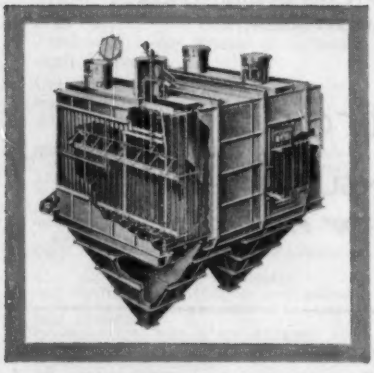
Address .....

City ..... Zone .... State .....

* ® Armstrong Cork Company, manufactured for Armstrong by Owens-Corning Fiberglas Corp.

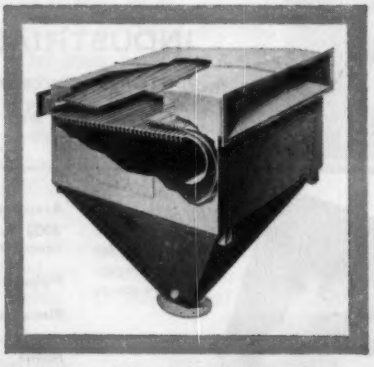
How Buell's exclusive Shave-off pays off in extra dust collection efficiency





Buell SF Electric Precipitator also delivers extra dust collection efficiency, due to unique Spiralectrodes and Continuous Cycle Rapping.

Proper proportioning, side entry of dust-laden gases, add even more extra efficiency and long, maintenance-free life to Buell Cyclones. Large diameter design eliminates bridging and clogging, keeps efficiency high under varying loads.



Buell Low Resistance Fly Ash Collector combines top efficiency with low draft loss, for either natural or mechanical draft installations.

For more specific data about Buell's *extra efficiency*, write Dept. 19-C, Buell Engineering Company, 70 Pine Street, New York 5, N. Y.

buell

MECHANICAL ELECTRICAL *Experts at delivering Extra Efficiency in* **DUST COLLECTION SYSTEMS**

A Quick Look at the Industry THIS MONTH

Hectic Month for Refiners . . .

Government probes and accusations—yield adjustments and cutbacks in runs highlighted the past 30 refining days. Brief resume of developments:

- Refiners started adjusting runs to use less crude, produce less gasoline, step up fuel oil output to meet Europe export requirements. Result: February runs were below record January rate, falling just short of 200,000-bpd cutback asked by government. In mid-February runs dropped slightly under 8 million bpd for first time since week ending December 7.
- Independent refiners fired up their plea to ship more products to Europe—with little or no success.
- Federal spokesmen lashed out at the industry at beginning of February, saying MEEC was falling down on its commitments to ship 500,000 bpd of crude and fuel oil to Europe. However, at month's end another tune was being sung—shipments in final two weeks were knocking right on the door of commitments. Europe is now meeting up to 80 percent of its oil needs.

—•—

Refining Outlook . . .

Prediction: Refined product inventories will look much better after first quarter (March 31)—refined product stocks will drop 56 million barrels, twice seasonal reduction of 28 million barrels in first quarter of '56—domestic demand will average 9.89 million bpd, 4.5 percent over first quarter of '56—export demand will average 765,000 bpd, up 156.7 over year ago.

—•—

Price Hike Will Stick . . .

January crude and gasoline price hikes were given a firm hold last month. Excellent presentation of industry economic facts of life by Hines Baker (Humble), Frank Porter (API), Gen. E. O. Thompson (Texas R.R. Comm.), Russell Brown (IPAA) and others have changed many a strong opinion in government circles—in favor of oil. Generally, oil spokesmen agreed that price boosts were made for four reasons:

- Known domestic crude reserves are declining in ratio to demand.
- Costs of labor and materials have shot up since 1947—considerably out of proportion to the two general price increases during same period.
- Drop in rate of return on investments.
- Rapid incease in export demand resulting from Europe Oil Lift.

—•—

Labor and the Refiner . . .

OCAW and independent union negotiations are underway at most Gulf Coast refineries. Early pattern indicates '57 goal is minimum increase of 25 cents per hour. Question: Will President Eisenhower's request to hold back industry wage increases have any effect on oil's union-management talks?

—•—

New Competitor for Polyethylene? . . .

Several American companies are taking close look at possibilities of isotactic polypropylene being made in Italian pilot plant.

Early (IP) research indicates following advantages: Appears to be twice as strong and more rigid than ordinary polyethylene—has about the same tensile strength as new high density polyethylenes—melting point is higher than linear polyethylene.

Chew Longer With Epoxy Resin . . .

Army is in third year of research program to find plastic coating and catalyst combination to paint on teeth. Object: Protective cover to prevent cavities. Chief researcher says he is on right track with epoxy resin applied to teeth cleaned with chloroform or alcohol. Obstacle: Hasn't found way to make it adhere.

—●—

Butyl—the Silent Synthetic . . .

Butyl rubber tires are proving far better than expected in actual commercial tests. Results are so favorable auto manufacturers may soon demand an all-butyl tire. Reason: Butyl is so silent, sound insulation requirements could be reduced in cost up to $300 on new cars.

—●—

Wolf Call for Engineers . . .

Growing need for more engineers is beginning to break down management's traditional notion it can't employ women as engineers. In fact, some top companies are emitting loud wolf calls for engineers with feminine gender. E. I. du Pont de Nemours & Company employs 300 women with technical degrees. Union Carbide and Carbon hired 40 women with technical degrees in '55.

—●—

Oil Shale Studies Continue . . .

Several major oil companies are studying feasibility of producing oil shales in western Colorado, the Athabasca tar sands of Canada and tar mats of western Venezuela using *in situ* combustion methods. Big question is whether pay formations have sufficient permeability to air to make such methods workable.

—●—

More Gas Plants on Gulf Coast . . .

Look for large gas processing plants to spring up on Louisiana Gulf Coast. Behind new trend are big volumes of gas now becoming available from offshore oil production. Pipe lines from producing areas can concentrate supply of gas for large plants before it goes into transmission lines. Alternate tack that still hasn't died: Build smaller processing units on offshore platforms.

After processing plants get going, next step will be for petrochemical ventures to nestle up to these hydrocarbon raw materials.

—●—

Plastic Pipe for Chemical Plants . . .

Fibercast Corp. (Youngstown Sheet and Tube) is first to commercially produce plastic pipe that will hold at least 50 atmospheres pressure—take temperatures over 220 degrees—stand up under corrosive chemicals.

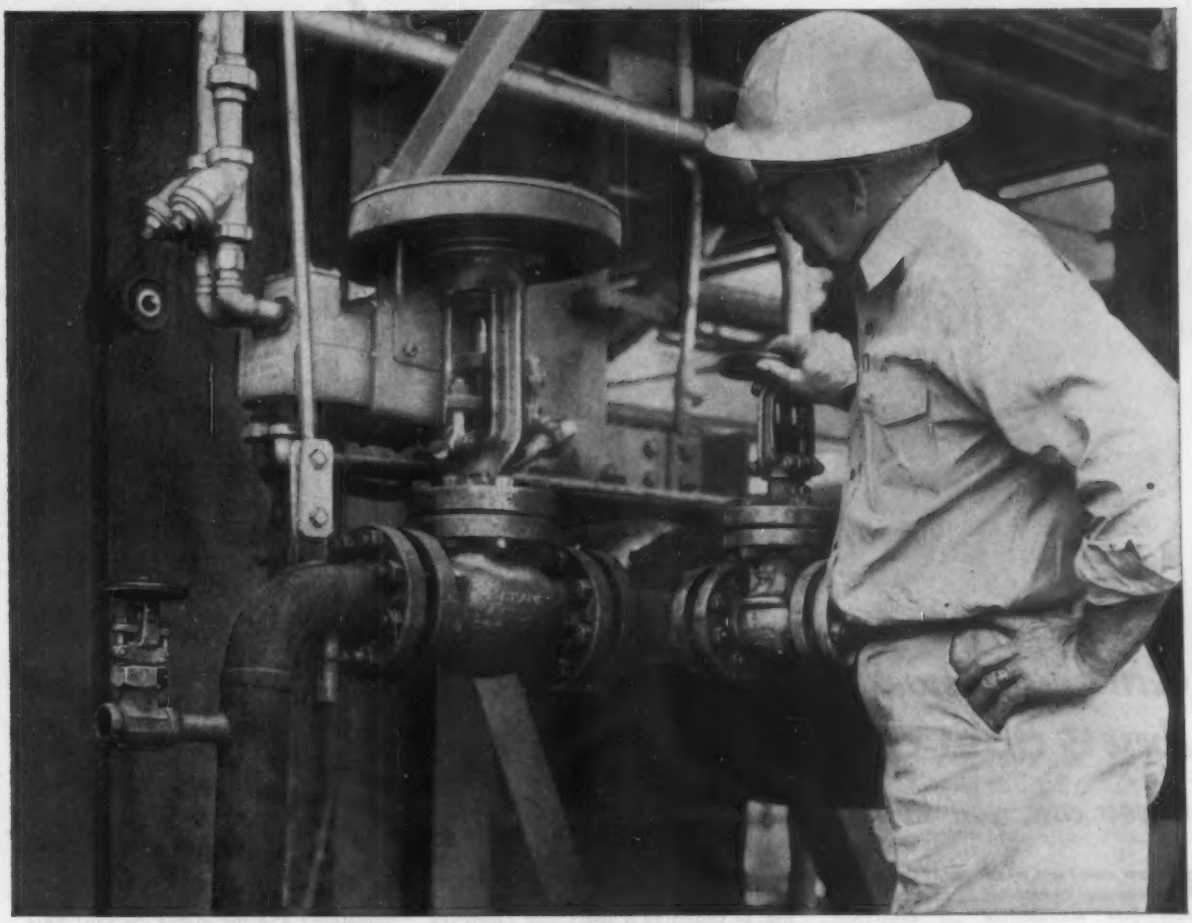
Pipe, made by casting epoxy resin around braided fiber glass sleeve, weighs one-fifth as much as steel. Full production is expected in June. Some chemical companies have already selected epoxy pipe for line service.

—●—

New Fields Show Promise . . .

The year opened with the discovery of 96 new U. S. oil fields. Most of January's finds were of the common "garden" variety, but as usual several stood out from the rest. Two of these were the best ones found in Mississippi in a number of years. They were: The California Co.'s discovery in Smith County making 266 barrels of 42-gravity oil per day; and Central Oil Co.'s strike in Simpson County good for 247 barrels of 45-gravity.

Other substantial discoveries were: Two new fields in Fisher County, North Central Texas, by Sinclair and Good Earth Oil & Gas rated at 363 barrels of 41-gravity and 1100 barrels of 41-gravity, respectively; an offshore strike in Jefferson County, Texas, by Pan American (Stanolind) good for 268 barrels.



15 years on 1050° F. blowdown service—still no maintenance on this Crane valve

THE CASE HISTORY—Continuous performance since 1941 on re-cycle gas blowdown, with not a single nut loosened for maintenance—that's the record behind this Crane No. 151X 300-pound steel globe valve.

Installed in a leading Texas refinery, this 3-in. motor-operated Crane valve not only is free of service costs, but is still operating like the day it was put in the line. Trouble-free and never leaking, it looks good for service indefinitely.

There's a reason for valve performance like this. It's in a century of quality valve building experience. Crane design makes the valve right for the job . . . Crane materials and manufacturing skill keep it on the job.

Don't be misled by outside similarity with Crane steel valves. The critical difference is inside. That's where Crane quality insures dependable oil refinery flow control and important savings in your piping maintenance costs.

Whatever your needs in quality steel valves, the Crane line fills them—in sizes up to 24 in., in pressure classes up to 2500 psi. Get the facts from your local Crane Representative, or write to address below.

CRANE VALVES & FITTINGS

PIPE • KITCHENS • PLUMBING • HEATING

Since 1855—Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers Serving All Areas

For more data on advertised products, use Readers' Service Cards, last page.

Can you answer these **5 cost-cutting questions** *about big-tank mixers?*

If you can, you know how to get most efficient mixing for your company

1 How can I get mixer shaft seals that meet any operating conditions? It's easy—just standardize on LIGHTNIN Mixers for your big tanks. Get your choice of *four* standard stuffing boxes, or a wide choice of rotary mechanical seals. With LIGHTNINS, you're sure of getting the *right* shaft seal for years of trouble-free mixing or blending.

2 What's the advantage of LIGHTNIN cartridge-type rotary mechanical shaft seal? No stuffing box to repack or maintain. You can replace the LIGHTNIN Seal in minutes, if it ever wears out. No need to drain the tank or dismantle the mixer; no need for special skill—you're back in operation fast! Many users of the LIGHTNIN Seal are saving thousands of dollars per year with this exclusive feature.

3 What's the quickest, simplest way to shut off tank contents before repacking, or changing a seal? The LIGHTNIN way! Easy-to-get-at handles are out in the open, always accessible. A few turns provide quick, positive shutoff of tank contents from mixer. Only LIGHTNIN gives you this time-saving advantage.

4 What mixer gives me most protection of the drive gears? LIGHTNIN again! The mixer shaft, in LIGHTNIN gear drive models, passes through a hollow drive quill. Shaft and quill are supported by separate sets of bearings, connected only by a flexible coupling. This coupling cushions shaft flexures and strains—keeps excessive shock loads from ever reaching the gearing. This construction adds years of safe operating life.

5 What's a good way to keep motor safe from dirt, dust, excessive moisture? Put the motor on top! This design, exclusive with LIGHTNIN, not only protects the motor; it centers weight closer to tank wall. You can choose standard foot-mounted motors, as shown, or round-frame NEMA Type P flange-mounted motors in all enclosures and all current characteristics. All motors are fully guaranteed.

These are just five of the engineering reasons why you get better, lower-cost mixing with LIGHTNIN Mixers. Your nearby LIGHTNIN representative can show you more. For quick, competent help on fluid mixing, look him up in Refinery Catalog. Or write us direct.

CUT MAINTENANCE COST with this quickly replaceable cartridge-type rotary seal, available on all LIGHTNIN Side Entering Mixers. Seal takes the place of a stuffing box; ends repacking for good; runs for years without adjustment; slides off for fast, easy replacement.

Lightnin® Mixers

MIXCO fluid mixing specialists

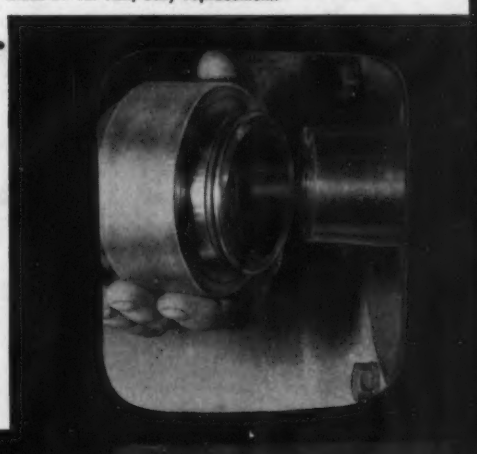
☐ ***Quick!*** **Send us the cost-cutting facts on LIGHTNIN Rotary Mechanical Seals—Bulletin B-111. We'd also like catalog information on these LIGHTNIN Mixers:**

- ☐ B-102—Top or bottom entering; turbine, paddle, and propeller types: 1 to 500 HP
- ☐ B-103—Top entering propeller types: ¼ to 3 HP
- ☐ B-104—Side entering: 1 to 25 HP
- ☐ B-108—Portable: ⅛ to 3 HP
- ☐ B-112 Laboratory and small-batch production types
- ☐ B-110—Condensed catalog showing all types
- ☐ B-107—Data sheet for figuring mixer requirements

Check, clip, and mail with your name, title, company address to:

MIXING EQUIPMENT Co., Inc., 164-c Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., Toronto 10, Ont.



Truly, Now Is the Time for Action

THE TENTACLES of creeping socialism are pulling tighter. Within the past 60 days a varied assortment of federal groups have:

- Threatened government control of refining and production to get more oil for Europe.
- Launched at least three investigations into recent crude and gasoline price increases.
- Stepped up attacks on oil's marketing operations.
- Called in the FBI to check the industry's economic operations.

The oil industry can no longer treat these government slaps like a pesky pup that, if left alone long enough, will go away. The pup is turning vicious, and if not discouraged—or enlightened, may well bring an ignominous end to the oil industry as private enterprise.

There is a way to discourage oil's critics, both in and outside government circles—an excellent way: *Present them, and the American public, with the facts—the reasons behind the actions.* It won't be easy to implement, but it must be done if the industry hopes to shake itself free of government control.

The facts and reasons must be given to every member of federal and state government—to every oil industry employe—to every company stockholder—to every resident of every community in which oil companies live—to every individual who pays the higher prices for gasoline.

These groups are entitled to the facts. The oil industry has the facts—and they more than justify the action. Now is the time to present them.

The first step is up to top management. Willingness to present the facts—reasons for presenting them—the facts themselves—full directions for dissemination—all must come from the top. Industry action will be a direct reflection of the attitude of the policy makers.

Although incentive and direction must come from the top, an equal responsibility rests with the industry's two million employes. It is their responsibility to learn the reasons behind industry actions—to have the right answers when non-industry individuals and groups ask critical questions, or make statements about oil that are untrue.

In short, it is the responsibility of *every* individual in the oil business to take an active part in creating and maintaining public understanding. The future of the industry may well be determined by the way in which this responsibility is met.

To help in the presentation of the facts, PETROLEUM REFINER has checked a number of reliable sources to compile accurate statistics which prove that oil's actions in the recent price increases were more than justified. The results are startling, as you will see when you read the eight-page supplement which accompanies this issue.

After you have finished reading oil's side of the story, please pass it on to a non-industry friend. It will take him but a few moments to realize that oil products are still the biggest bargain in America compared with many products—despite mounting costs. If you would like more copies to send to individuals or groups, they are available at nominal cost.

No matter how you do it—help keep the oil industry free.

Truly, now is the time for those interested to act.

Oil Brains Can Help Here, Too

WHETHER THE OIL INDUSTRY can be charged even remotely with the mounting toll of lives taken by automobile accidents is a question that we will leave for those more inclined to debate. Competition has resulted in gasoline of higher quality as automotive manufacturers from year to year continue to increase both the horsepower and the compression ratio of cars. Whether the oil industry is permitting the auto manufacturers to lead them around too much by the nose could be thrown into the same debate.

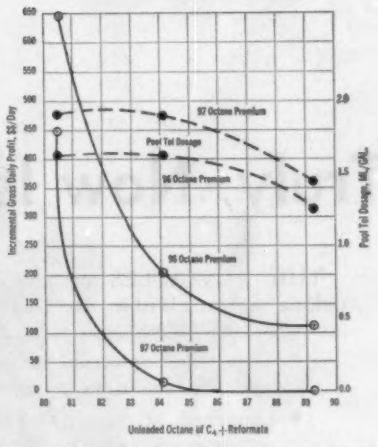
What is non-debatable is the awful fact that motor vehicle accidents remain the nation's No. 1 accident killer. Despite the increase in driver training, the improvement in road engineering, and the over-all tendency for stricter law enforcement—all most commendable—1956 saw a 4-percent gain in traffic deaths. This increase was the reason for the higher all-accident total for the year, according to figures recently announced by the National Safety Council.

There were 95,000 accidental deaths during the year with 40,000 of these resulting from motor

TABLE I
Economic Study of Catalytic Reforming Operations

Reformer Operation	Design	Lo Level	Hi Level	Down
C_4+Product Clear Research Number	84.2	81.1	89.3	Jet Fuel
Pool TEL Dosage Ml./Gal.	1.625/1.895	1.65/1.92	1.275/1.44	2.685/2.97
Premium Octane Level	96/97	96/97	96/97	96/97
Product Realization, $/CD	38880	39205	38625	30885
Variable Costs, $/CD				
96 Premium	2965	2850	2805	2965
97 Premium	3160	3045	2920	3125
Net Gross Realization, $/CD				
96 Premium	35915	36355	35820	27920
97 Premium	35720	36160	35705	27760
Incremental Gross Profit, $/CD				
96 Premium	210	650	115	
97 Premium	15	455	0	
Jet Fuel Break-Even with Best Performance Case, $/CD				
96 Premium—11.2c/Gal.				8435
97 Premium—11.1c/Gal.				8400

FIGURE I
Economic Study of Catalytic Reforming Operations



A SMALL REFINER'S PROFIT GOES UP $400 PER DAY! Du Pont's economic study recently helped a progressive refiner realize optimum performance with a newly installed catalytic reformer. Three operating conditions were compared—low-level, design, and high-level severity. Two premium gasoline octane levels, as well as jet fuel production, were considered. The above table and graph (right) pointed up the proper severity level for the refinery being studied.

These charts show how Du Pont helped a refiner ...get higher octane at lower cost

The demand for higher-octane fuels places new and increased importance on the question: How can those extra octane numbers be achieved at lowest cost?

This subject has often come up for consideration at Du Pont, especially during analyses of refinery operations and the effect of these operations on tetraethyl lead requirements.

A Du Pont service

As a result of the knowledge and experience gained in this way, our technologists have been able to help a number of refiners cut octane-improvement costs.

You can call on Du Pont to work with your own staff to develop more economical ways of boosting octane levels, or to confirm the findings of your group. Or you may prefer to have our technical representatives consider your facilities and make recommendations to fit your individual needs.

In any case you need only contact the nearest Petroleum Chemicals Division office listed at right.

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vehicle mishaps on our highways.

What a terrible blot upon a nation's record! In addition to the tears and grief and suffering resulting from sudden death to 40,000 people, some of them your colleagues or neighbors, think of the terrific economic waste attending.

(In arriving at its estimate of an "economic loss of $10.8 billion," the Council includes the 95,000 deaths from all accidental causes as well as nonfatal accidents. Wage losses, medical expense and overhead costs of insurance for all accidents, production delays, damage to equipment in work accidents and property damage from traffic accidents and fires comprise the items in this category.)

A national disgrace, it has been called. And, to repeat, that statement is hardly debatable.

The oil industry very likely has no greater responsibility than any of a hundred other industries that might be named. But even at that, a share of the responsibility is ours because we have suffered as have all others to the degree that many of our own people have lost their lives, in too many instances, needlessly. So it behooves us as an industry interested in national as well as our own welfare to continue to preach and to train and to educate with all the power that's in us. Our individual and collective safety setups must keep everlastingly at the task of trying to help remedy a bad situation that apparently isn't going to remedy itself.

It's a challenge to the best brains in America. And many of our own people are included in that group, too.

The 'Nose' Has It

PARDON US for a brief bit of nostalgia—but imagine not being able to sniff the familiar aroma of gasoline while the station attendant fills 'er up!

The situation may never become that bad, but some industry experts are convinced that oil products must have pleasant odors if they are to sell. Not the Chanel No. 5 or Evening in Paris kind of smell—just not obnoxious.

In the past, oil companies have paid relatively little attention to the odor of their products with the exception of paraffin wax, white oil and mineral spirits. Now, considerable attention is given to solvents.

For many years refiners have manufactured a special deodorized kerosine for insecticide purposes, but paid less attention to the odor of other solvents. In the past few years, so-called odorless mineral spirits have appeared on the market. They are the basis for the "odorless" base paints. This has resulted in more attention being paid to the odor of conventional paint thinners.

Esso Standard Oil Company recently announced it has one or more panels of odor experts who evaluate products at each of the company's domestic refineries and research divisions, and at a number of the European Laboratories and refineries as part of an odor control program. The Esso researchers keep a complete set of books on the odors of waxes, white oils, solvents, kerosine, gasoline and heating oil. In fact, Esso says that in its refinery expansion program, new units are built to produce the best quality products—and odor is practically always considered as one of the important qualities.

The odor researchers' aim is not to produce products that smell like perfume, but to keep the odor of the product at such a level that it does not become obnoxious to the consumer. Everyone expects gasoline to smell like gasoline and heating oil to smell like heating oil—but no one wants to have it smell like a New England spoiled dinner.

Gasoline Stocks in Good Balance

THE REFINING INDUSTRY has done a magnificent job of lowering its operations and product output during the past few critical weeks. Such a move was deemed necessary by industry observers to prevent gasoline inventories from becoming completely out-of-line with the nation's needs, and at the same time making more crude oil available for shipment to Europe.

Refinery crude runs dropped to 7,795,000 barrels daily during the week ended February 22. That was a decrease of 181,000 barrels a day from the previous week's rate, and 410,000 barrels less than the all-time peak daily rate reached in January.

Resulting from these reduced refining rates was lowered gasoline output. During the week ended February 22, motor fuel production amounted to 3,668,000 barrels daily, while a week previous this production totaled 3,761,000 barrels a day. Same product output during January averaged 3,900,000 barrels daily.

This has resulted in vast improvement in the gasoline inventory situation. Although stocks have continued to rise, and are now at an all-time high mark, recent weeks have seen them advance at a slower rate, and are at present nearer to year-before levels than they have been in a year or more.

Gasoline stocks had risen to the peak of 204,122,000 barrels by February 22, but even then they were only slightly more than 10 million barrels greater than they had been a year earlier. That amounted to a gain of only 5.2 percent during the year, and not out-of-line with increased demand for the fuel.

If gasoline output is held around current levels until the end of March, there need be little fear of excessive stocks situation or a resulting weakening price structure.

ETHYL STUDY ANALYZES INDUSTRY OCTANE POTENTIAL TO 1960

New report can help in your future refining plans

by C. J. WOLF, Ethyl Corporation Refinery Technologist

Ethyl Corporation has undertaken this study to evaluate the effects of present and future refinery processes on the antiknock quality of the motor-gasoline pool in the United States.

The octane potential of the United States refining industry from 1955 to 1960 has been analyzed for the United States as a whole and, separately, for the various regions—East, Midwest, Gulf, Rocky Mountain, and West Coast. The effects of present and future refinery processes in general, and the catalytic reforming process in particular, have been the primary variables evaluated.

Secondarily, changes in crude type, the ratio of domestic-to-foreign crude run, and the composition and disposition of those products from petroleum that influence the quality and yield of gasoline have also been taken into account.

Influence of refining techniques

ETHYL studies indicate that the octane number of the total motor-gasoline pool in the United States increased by 0.9 Research octane number (RON) and by 0.8 Motor octane number (MON) from the fall of 1955 to the fall of 1956.

During this period, the portion of the U.S. refining industry utilizing catalytic reforming increased from 66 to 81 per cent (based on projected crude-running capacity). Total catalytic-reforming capacity, including spare capacity, increased from 10.6 per cent of crude run in 1955 to 12.9 in 1956.

Industry saturation of catalytic reforming in this country as a whole has been estimated at 16.0 per cent of crude run. This saturation is for virgin-naphtha feed only, and it is estimated that it will be reached in the fall of 1957.

Saturation of catalytic reforming is expected to take place by this time in all regions of the U.S. except in the Rocky Mountain region, where saturation is forecast for the fall of 1958.

The octane potential after the fall of 1957 will primarily be influenced by the severity of catalytic reforming, catalytic reforming of heavy thermal naphtha, aromatic extraction with raffinate recycle, and maximum use of alkylation for motor fuel after compliance with aviation-gasoline demand.

A summary of the catalytic-reforming growth in the United States is presented in the table below.

The effects of the growth or decline of refinery processes other than catalytic reforming during the 1955-1960 period have also been evaluated in this study. Growth is expected in catalytic cracking, catalytic polymerization, and alkylation in terms of percentage of crude run, during this period. In the same terms, decline is expected in thermal operations—visbreaking, coking, and thermal cracking.

CATALYTIC REFORMING

Per Cent of Crude Run

Fall of Year	1955	1956	1957
East	9.4	11.7	17.0
Midwest	11.0	13.1	16.9
Gulf	10.8	13.7	15.1
Rocky Mountain	1.9	7.2	11.9
West Coast	12.7	13.7	15.9
Total U. S.	**10.6**	**12.9**	**16.0**

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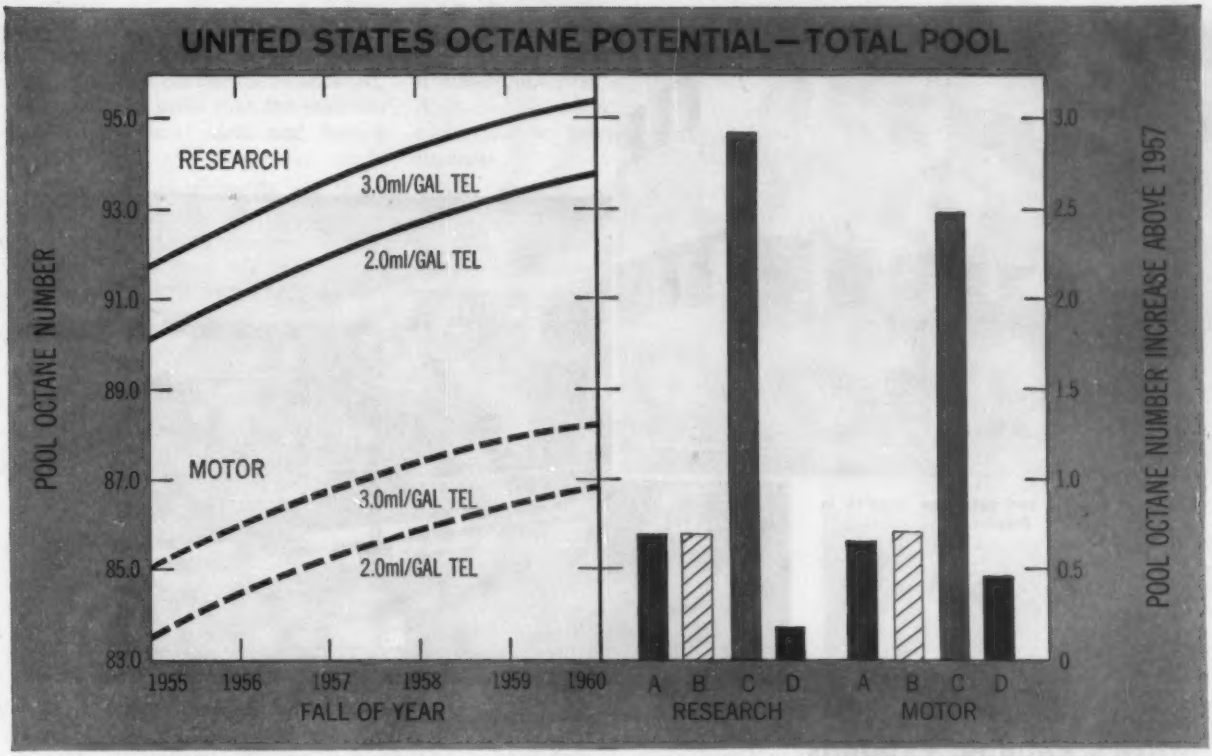

The weighted regional-pool octane number potentials of total U.S. pool gasoline are shown from 1955 to 1960. The maximum octane increases obtainable from: **A.** increased reforming severity, **B.** reforming heavy thermal naphtha, **C.** aromatic extraction and reforming raffinate from straight run charge, and **D.** maximum alkylation are shown for the total U. S. gasoline pool. The weighted proportions of these refinery processes in use after 1957 were calculated from projected refinery economics.

Thermal reforming, with the exception of that planned for use in conjunction with catalytic reforming, has been considered to be non-existent when saturation of catalytic reforming of virgin-naphtha is achieved in 1957.

Increases after 1957

AFTER 1957, the maximum octane increase obtainable by more severe catalytic reforming, use of reforming capacity for heavy thermal-naphtha charge, aromatic extraction and raffinate recycle, and maximum alkylation will be about 4.6 RON and 4.2 MON for the total United States.

Depending on the region, this maximum potential octane increase can range from 4.2 to 5.2 RON and from 3.8 to 5.0 MON. The amount of this maximum potential octane increase that is actually employed by 1960 will vary from region to region.

Use of the above-cited refinery processes by 1960 could increase antiknock value of the total 1957 United States pool by about 1.7 RON.

The costs of octane improvement and local area conditions will dictate relative use of these more severe refinery operations.

In general, it is felt that increasing reforming severity to average a yield of about 80 per cent debutanized reformate will be almost universally employed throughout the industry by 1960.

The use of aromatic extraction and raffinate recycle and of catalytic-reforming capacity for heavy thermal-naphtha charge will be practiced by only one-third of the industry in 1960. It is believed that use of these processes will vary between 0 and 40 per cent, depending on the region.

Maximum alkylation above and beyond that required for aviation gasoline will be practiced by about 20 per cent of the industry as a whole, and in the various regions, with the exception of the Rocky Mountain area.

HOW ETHYL RESEARCH CAN HELP YOU

To assist refiners in obtaining the most economical routes to high-octane fuels, Ethyl Research maintains a close watch on trends in refinery processing. Recent studies of crude sources, processing and product yields provide a realistic evaluation of the octane potentialities of motor gasolines. The major findings are summarized for you here. A complete report entitled "U.S. Refining Octane Potential 1955-1960" is available through your Ethyl Representative.

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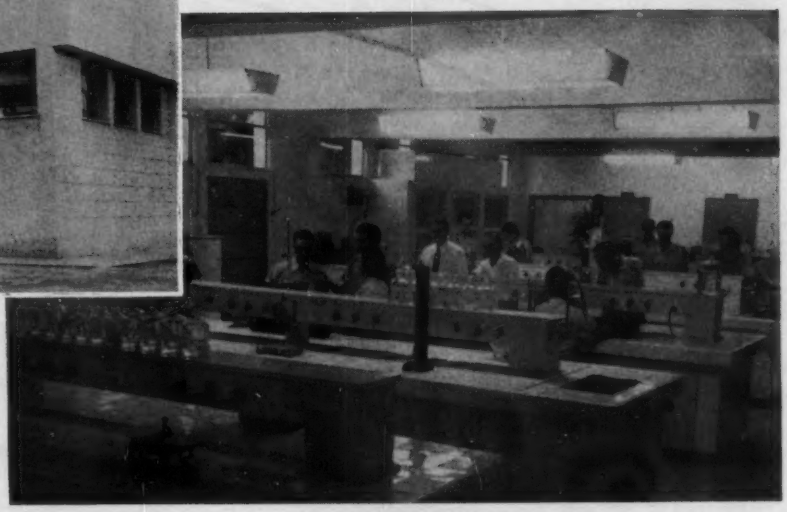
Center of training and petroleum research in Brazil.



Analytical control laboratory.

Brazil's Refining Expands

Unique School Provides Engineers

Brazil is meeting its critical needs for engineers through the cooperative efforts of a U. S. professor, the University of Brazil and National Petroleum Council.

F. Campbell Williams and Antonio Seabra Moggi
Centro de Aperfeicoamento E Pesquisas de Petróleo
Rio de Janeiro

SINCE 1950, Brazil has expanded its refining facilities from one 3000 barrel-per-day plant to five refineries totaling 110,000 bpd. Existing refineries are being expanded and new refineries are being built that will increase capacity another 115,000 bpd, including a 2500 bpd lube oil plant.

This rapid growth has created a critical need for refinery engineers who are not only proficient technically, but who are also capable administrators and leaders. That need is being filled by an unusual refinery school created by the National Petroleum Council and now financed and operated by Petróleo Brasileiro S/A with the cooperation of the University of Brazil.

How the School Was Started—Early in 1951, the administrative engineers of the National Petroleum Council and professors from the University of Brazil met to consider staffing the new refineries then being built.

They found one major problem at the outset: Brazilian universities were patterned after the European schools, i.e., engineers were graduated with theoretical descriptive knowledge, but without any practical application in engineering problems. To meet the problem, the National Petroleum Council created a special refinery school. The University of Brazil cooperated by offering the use of its laboratories at the school of chemistry in Rio De Janeiro, and by awarding a special diploma to the graduates.

Professor Kenneth Kobe of the University of Texas was asked to come to Brazil to study the available facilities and to make concrete recommendations for the organization of the school. On his suggestion three American engineers were hired to develop the course and to train Brazilian professors as replacements.

Course Stresses Fundamentals—The course begins with a thorough foundation of chemical engineering and petroleum refining. These principles are taught and reinforced with realistic problems taken from industry.

The philosophy of the school is to develop in the young engineer the ability to think logically and to develop self confidence in his work. As the time passes, his creative ability is developed. He begins to use a logical and systematic approach. He soon finds that this approach can be

applied to successful solution of any engineering or administrative problem. With this confidence established, the professors insist that the students propose original ideas and defend them.

After the fundamentals are thoroughly understood, more and more refinery operating material is presented. This is done by utilizing the laboratory, the refineries and conference discussions. Midway in the year the students move to a five-week practice course in one of Brazil's refineries. Here they actually are placed on shifts as operators under the supervision of the refinery engineers. Three weeks are devoted to operations and two weeks to technical service.

In all of their work, including the practice school, the importance of technical writing and communications is stressed. After the practice work, the last three months in class and laboratory take on a new aspect. The approach now is to give general problems, with several possible solutions, for evaluation.

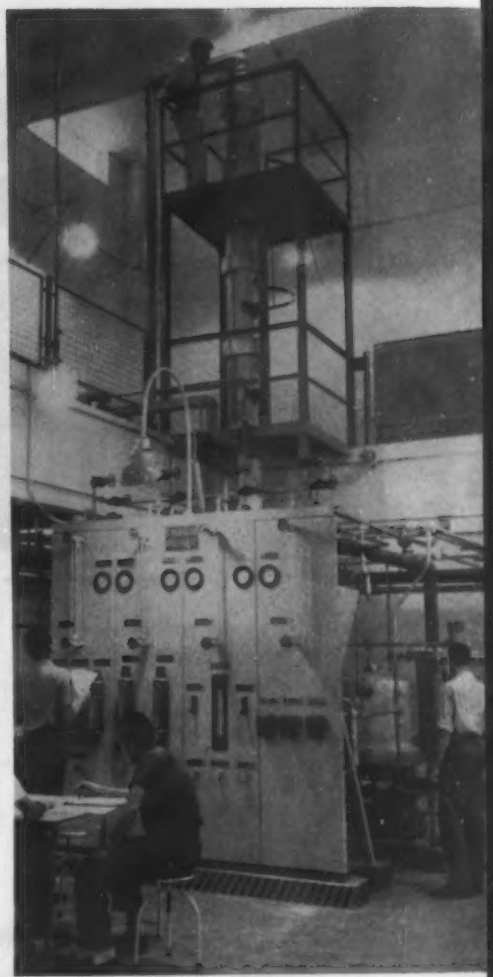
Teams of the students work together—evaluating, presenting and defending their solutions. Seminar and conference discussions of the problems have proved very successful. One of the reasons for such success is that a low ratio of students to professors is maintained. The graduate is therefore well trained technically. In addition, emphasis is placed on important personal qualifications. Before the student enters the main course he takes a six week review covering basic material. Here he is closely observed by the professors. A careful selection is made to limit each class to between 10 and 20 students.

Also, each student is tested by a group of prominent psychologists to see if he has suitable characteristics for an operating supervisor in the refinery. A later check of these men in the refinery has given good confirmation to the predictions of the psychologists.

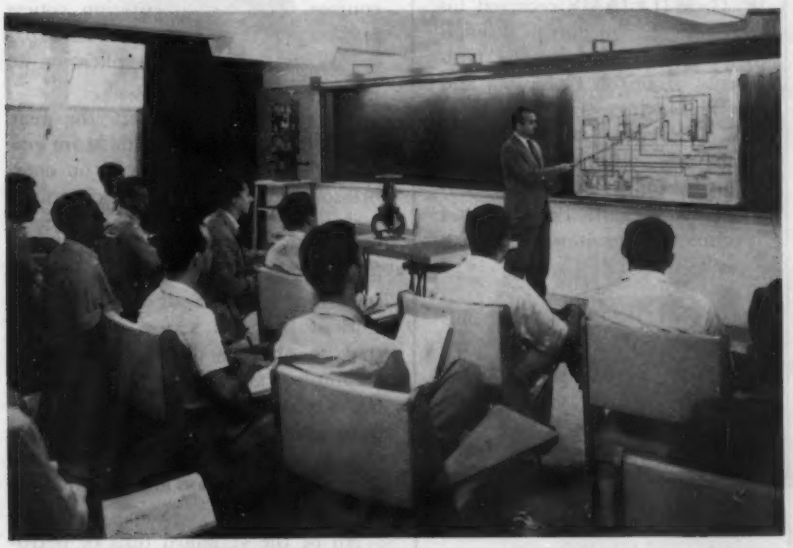
Students Are Rated—During the course each professor rates the student on attitude, ability to learn, personality, industry, and initiative. These ratings are averaged and enter into each course with a weight of 5 percent. The rating sheets are regularly discussed with each student and aid Petrobras in placing the engineers.

At the present, Brazil's refineries need young engineers with initiative and leadership. Consequently emphasis is placed on personnel problems, management, professional ethics, responsibilities and leadership. In addition stimulation is constantly given for continued education. It is not uncommon for graduates to write to the school requesting the latest information on some new development in refining technique.

The school selects only those who are graduates of the better universities and colleges of Brazil. The students who are chosen may accept a fellowship which compares favorably with a starting salary for university graduates. In this latter case Petróleo Brasileiro (Petrobras) signs an agreement with the student. They guarantee to pay a good starting salary upon graduation and to give increases after refinery experience.



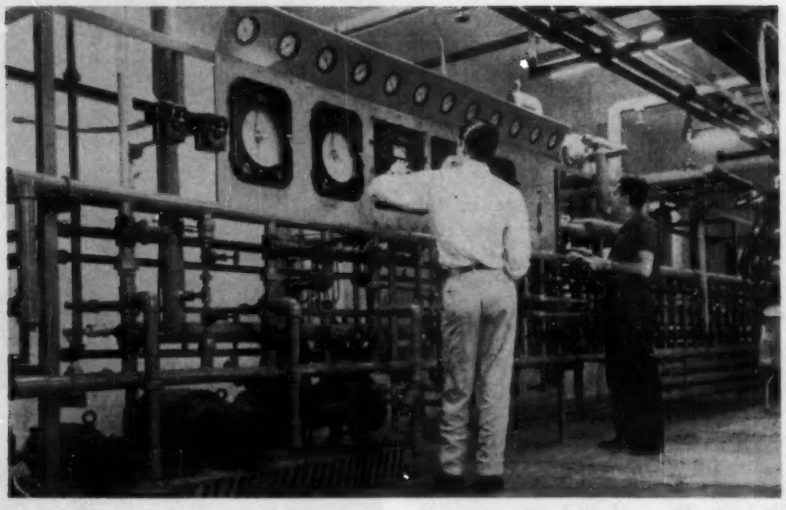
Distillation pilot plant in unit operations laboratory.



Petroleum refining engineers in conference room.

The engineer agrees to work for the company for two years at the refinery chosen by Petrobras. However, a student may refuse the fellowship and attend the school with no obligation to work for Petrobras.

Curriculum Is Intensive—The Petrobras school consists of an intensive curriculum of one full year, broken into three 15-week periods. Class work averages 40 hours a week while home work will average four hours per night. Students are checked carefully and rigorously during each



Fluid flow and heat transfer equipment with instruments.

period. Each student must meet a specified term average and accumulative grade average to remain in the course. Upon graduation they are guaranteed further practical training, usually abroad, and a position in one of Brazil's refineries.

The unit operation courses include heat transfer, fluid flow, distillation, absorption, extraction, filtration, cooling towers, fluidized beds, etc. The basic fundamentals are taught thoroughly. At frequent intervals short unannounced tests are given covering important and specific points in the application of the fundamentals.

Each lecture of one hour is followed by an hour of discussion where the student works problems and talks over his difficulties with the professors. Increasingly a new type of problem is introduced: operating conditions in a plant are changed and the student is asked to determine the effect of such changes.

In connection with each unit operation, a study of the equipment involved is made in the laboratory or on full scale equipment in a refinery. The unit operation laboratory is used to test existing theories, to acquaint the student with the accuracy of measurement, to develop creative powers and initiative, and to teach technical report writing.

During the laboratory work the students act as leaders of the others and are responsible for the final report which is usually a group effort. The forms of the report change depending upon the request of the imaginary refinery superintendent. Often these reports must include an analysis of the cost of doing the experimental work.

During the year the students are asked to select practical problems that require laboratory investigation. These problems cannot be routine but must take the form of a request for data that might be expected from a process design or technical service division.

The fundamentals of refining are taught with Nelson's *Petroleum Refining Engineering* as the basic text. Of course, this material is expanded and interpreted in the light of the operating experience possessed by the professors. The student goes into process design beginning with the design of a crude flash unit, followed by furnace operation and design.

After the five-week refinery practice course the students work in small groups on problems of broader scope involving both design and economics. The last term problem must be one that they themselves choose. Normally it is a redesign, study of process modifications, or expansion of the refineries which they have previously visited. The burden of selecting the problem is placed squarely on the student himself. An important phase in the solution of the problem is the preparation of a complete technical report.

Unnecessary repetition is avoided, but re-emphasis of important and basic points is practiced, nearly always with different approaches. Such subjects as refinery equipment, processes, and materials are closely knit to follow the calculations in other courses. The instrumentation course teaches the instrument and its capabilities as well as its application to the process.

Thermodynamics covers the real, rather than the ideal fluid. More emphasis than usual is placed on compressors, low temperature coolers, boilers, turbines, and internal combustion engines. Physical and chemical equilibrium are studied in detail. In all of these design courses the student becomes aware of the fact that in practice the data are often incomplete. Beginning with the initial problems the students are required to develop a feel for the sizes and quantities involved in order that they may make good engineering estimates.

All of the standard tests of petro-

Continued on Page 274

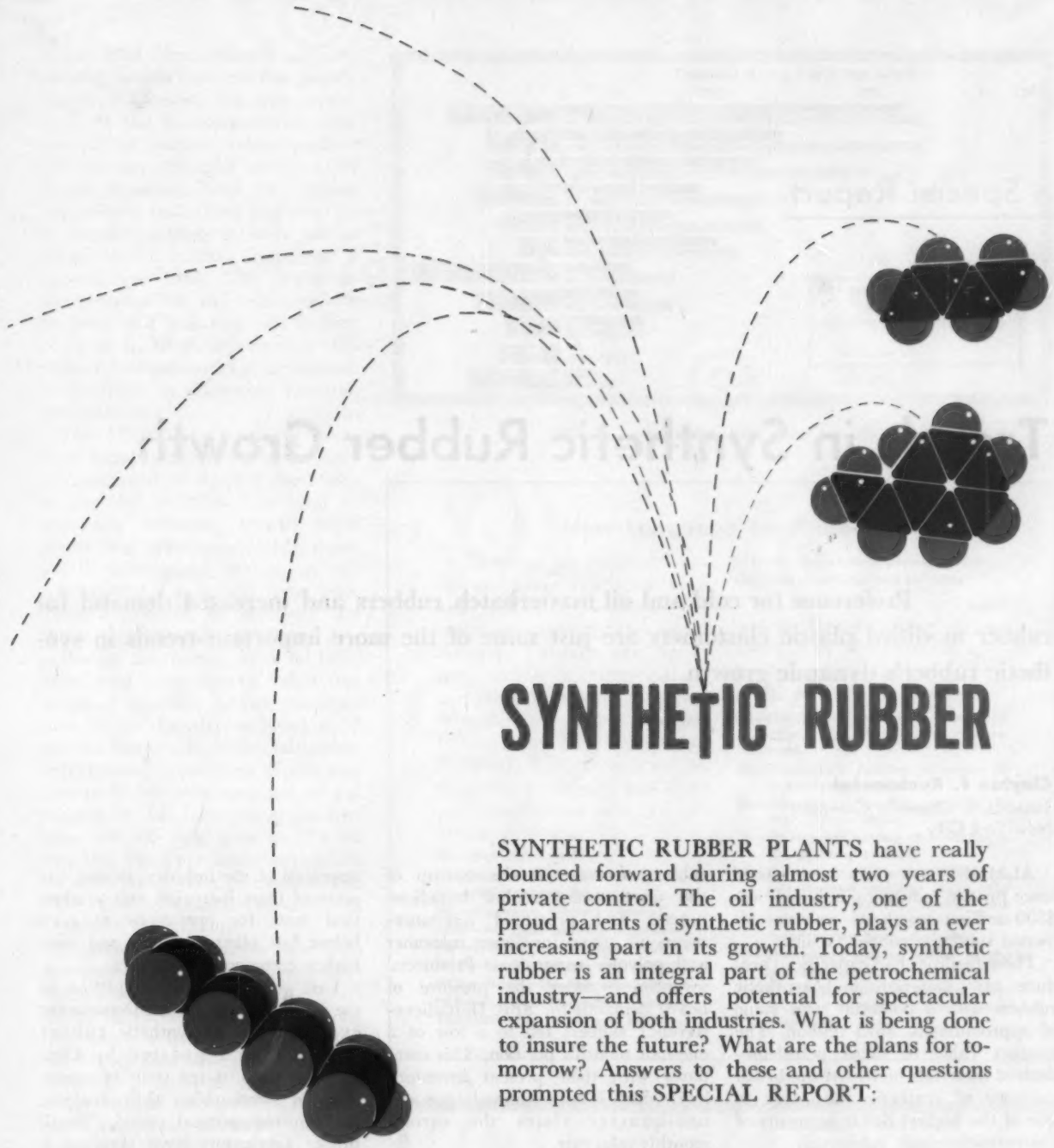
About the Authors

F. C. Williams A. S. Moggi

F. C. WILLIAMS received his B.S. degree in chemical engineering in 1943 from the University of British Columbia and his Ph.D. degree in 1948 from the University of Iowa. He spent three years with the Conselho Nacional de Petróleo, Brazil. He is presently Professor and Technical Consultant for Petrobras in Brazil.

•

A. S. MOGGI received his chemical engineering degree from the University of Brazil in 1944, and took postgraduate courses at both Vanderbilt University and Massachusetts Institute of Technology. He is presently employed by Petrobras as superintendent of the Research and Instruction Center.



SYNTHETIC RUBBER

SYNTHETIC RUBBER PLANTS have really bounced forward during almost two years of private control. The oil industry, one of the proud parents of synthetic rubber, plays an ever increasing part in its growth. Today, synthetic rubber is an integral part of the petrochemical industry—and offers potential for spectacular expansion of both industries. What is being done to insure the future? What are the plans for tomorrow? Answers to these and other questions prompted this SPECIAL REPORT:

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a Special Report

Trends in Synthetic Rubber Growth

Preference for cold and oil masterbatch rubbers and increased demand for rubber modified plastic elastomers are just some of the more important trends in synthetic rubber's dynamic growth.

Clayton F. Ruebensaal
Texas-U. S. Chemical Company
New York City

ALMOST two years have passed since private industry purchased over $300 million worth of government-owned synthetic rubber facilities.

These facilities had capacity to produce raw materials and synthetic rubbers with a potential sales value of approximately $675 million. The product value of these petroleum-derived materials increased the broad category of synthetic elastomers to one of the highest dollar segments of the petrochemicals industry.

The first 12 months of operation, starting with about May 1, 1955, was a profitable and eventful period of reorientation and growth. Profitable as it saw the industry operating almost continuously at above rated capacity before normal corporate expense levels had been attained. Eventful because of shortages resulting from the rubber industry's 1955 new rubber hydrocarbon wants which exceeded the high of previous years by 15 percent. This demand required production levels at rates unprecedented in the history of synthetic rubber, necessitated the startup of the uneconomic alcohol butadiene process and prompted announcements of plans for large monomer and polymer expansions. Producers' inventories under the pressure of heavy demands for SBR (butadiene-styrene) rubbers fell to a low of a one-half month's position. This compares with their present inventory level which is approximately one and one-quarter times the current monthly sales rate.

Concurrent with the buildup of producers' inventories, due to decreased rubber consumption in mid-1956, other factors also tended to cut seriously into profit margins. The factors causing rising production costs included increases in freight and labor rates and escalated utility and petroleum-derived feedstock prices coupled with higher depreciation costs on new plant facilities. These cost elements far outweigh a projected price decrease for styrene in mid-1957. This situation would indicate the need for an economic reappraisal of the industry, taking into account these increased unit production costs for operations at rates below full plant capacity and with higher commercial expenses.

Last year also saw completion of the initial annual Justice Department examination of synthetic rubber operations, as requested by Congress for the first ten years of operation. In summarizing their analysis, the attorney general stated, "Small rubber fabricators have obtained a fair share of the synthetic rubber produced and at fair prices." A summary of the statements of the small business customers concluded that they had experienced "improved relationships between buyer and seller as well as superior technical liaison and asistance and had found the quality of GR-S improved."

Unparalleled Expansion. Expansion was the keynote of these first two years. Breaking of bottlenecks accounted for a major share of the expansions in butadiene and SBR rub-

bers in 1955. New domestic capacity, resulting largely from the first private capital investments for new equipment in the butadiene-styrene segment of the synthetic rubber producing industry, brought about a 22 percent expansion from 1.15 million long tons to 1.4 million long tons for all synthetic rubbers in 1956. An increase to 1.6 million long tons is planned for 1957. The individual plant expansions and additions for domestic SBR producers will be seen in Figure 1. Other expansions in SBR rubbers are planned for completion in mid-1958 in Germany, England, and Italy.

The 549,000 short tons of butadiene capacity purchased by industry was increased to 650,000 short tons by the end of 1956. The total by mid-1958, including several small plants that were previously private and three completely new plants, will approximate 1.1 million short tons. These expansions, by company, are shown in accompanying Figure 2.

During the period 1955 to 1957, announced expansions in other segments of synthetic rubber manufacture in this country included a 73 percent increase in NBR (butadiene-acrylonitrile) types from 37,000 long tons to 64,000 long tons and an expansion in CR (neoprene) rubbers from 100,000 long tons to 125,000 long tons. Plans are under way abroad for a neoprene plant in England and a butadiene-acrylonitrile rubber plant expansion in Germany.

Although no expansions have been announced on the two previously government-owned IIR (butyl) manufacturing facilities totaling 90,000 long tons, one new domestic producer and one French firm have publicized their intentions to build plants. With these additions and the probable subsequent expansion of existing facilities some time in the next few years, butyl's capacity could be more than doubled by the early 1960's.

Reference has been made frequently to announcements of planned synthetic rubber facilities of all types, totaling 1.8 to 1.9 million long tons by 1960 and the fact that this synthetic rubber capacity is greater than the forecast *total* domestic rubber hydrocarbon consumption for any year in the same period.

This observation, without further amplification, leads to the conclusion that there are "excess facilities" rather than "seasonal periods of sur-

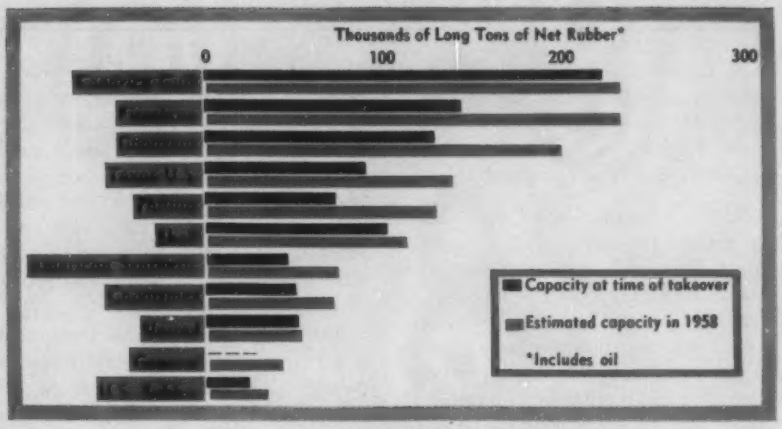

FIGURE 1—Styrene-butadiene rubber capacity.

New Language for Rubber

Old terms for synthetic rubber are being replaced by a new ASTM nomenclature recently approved by the rubber industry. To keep you up to date, articles in this special report have been edited to conform with this newest standard, known as ASTM Designation: D 1418-56 T "Nomenclature for Synthetic Elastomers and Latices." Here's what each new abbreviation means.

BR—Butadiene rubbers.
IR—Isoprene rubbers, synthetic.
CR—Chloroprene rubbers.
NR—Isoprene rubber, natural.
ABR—Acrylate-butadiene rubbers.
IIR—Isobutylene-isoprene rubbers.
NBR—Nitrile-butadiene rubbers.
NCR—Nitrile-chloroprene rubbers.
PBR—Pyridine-butadiene rubbers.
SBR—Styrene-butadiene rubbers.
SCR—Styrene-chloroprene rubbers.
SIR—Styrene-isoprene rubbers.

In addition these elastomers and rubbers are classified and coded from the chemical composition of the polymer chain in the following manner:

M—Elastomers having a saturated chain of the polymethylene type.
N—Elastomers having nitrogen in the polymer chain.
O—Elastomers having oxygen in the polymer chain.
P—Elastomers having phosphorus in the polymer chain.
R—Rubbers or elastomers having an unsaturated carbon chain, for example, natural rubber and synthetic rubbers derived at least partly from diolefins.
T—Elastomers having sulfur in the polymer chain.
U—Elastomers having carbon, oxygen, and nitrogen in the polymer chain.

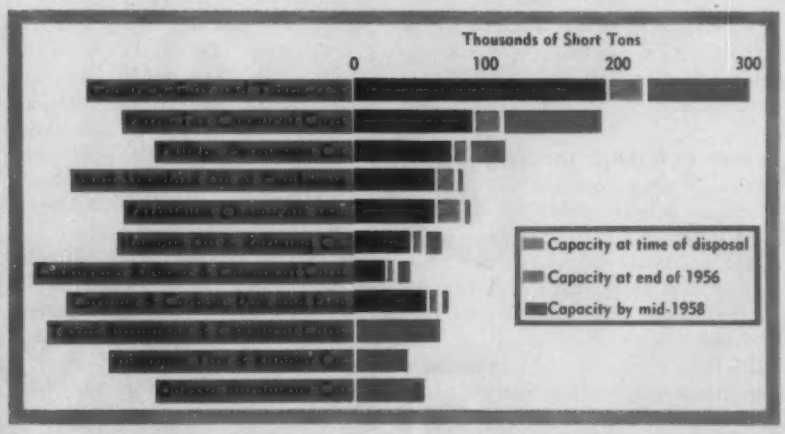

FIGURE 2—Existing and planned petroleum butadiene capacities.

plus capacity." Such a conclusion, however, overlooks the five following significant facts, any one of which could justify the seemingly "excess facilities" which are planned:

1. The aforementioned observation compares capacity with "average sales demands" rather than with "peak demands" which cannot be met by customary inventory procedures. The top consumption months in the past four years have exceeded average consumption by 8 percent to 16 percent. In every year of the same period there has been at least one month's total rubber consumption that has exceeded an annual ton rate of 1.425 million long tons, which is greater than the total productive capacity of all synthetics at the start of 1957.

2. Export demands on domestic synthetic capacity rose to 159,000 long tons per year in 1956 and could go to 250,000 annual long tons, whereas they were 94,000 long tons in 1955 and only 30,000 long tons in 1954.

3. Since the beginning of long range forecasting by the rubber industry—approximately 12 years ago—actual annual consumption in the rubber industry *has exceeded* by 6 percent to 40 percent the forecast figure that had been made for that year five years earlier.

4. Non-rubber uses (using the word "rubber" as classified today) are consuming synthetic rubber in continually increasing amounts in the form of chemical modifications or physical blends with other materials.

5. The expansions announced as "planned" appear likely to be on the optimistic side, both as to timing and actual tonnage.

Trends in Rubber Industry. Forthcoming events cast their statistical shadows. A number of trends have been noted in a statistical analysis of usage patterns. Trends in the SBR rubber field have included increasing preference for cold rubbers over hot, gradually increasing usage of oil masterbatch rubbers and decreasing percentage usage of the carbon black masterbatch types. Oil masterbatch types today constitute approximately 35 percent of the total net rubber content, and could possibly increase to a figure as high as 50 percent. Net SBR polymer in carbon black masterbatch types has decreased as a percentage of total dry net SBR polymer consumption each year from 1950 through last year but should start leveling off at its present figure of approximately 8 percent.

The most obvious and important of all trends is the increased usage of synthetic vs. natural rubber. As recently as 1947, consumption of natural rubber in the U. S. constituted over 50 percent of the world's natural rubber consumption and 60 percent of our own nation's total rubber hydrocarbon consumption. In 1956, 61 percent of the total U. S. rubber hydrocarbon consumption was synthetic with natural rubber's 39 percent, constituting slightly less than one-third of the world's natural rubber consumption. Synthetic rubber consumption has been forecast by many experts as approximately 65 percent of the total new rubber market in the U. S. by 1960. Other rubber economists have set this figure as high as 75 percent. The variance in these estimates might be attributed (in addition to the usual hazards of forecasting) to the question of whether we are forecasting "new rubber hydrocarbon" and its outlets as we know them today or whether we shall in the future include new rubber-like materials and new non-rubber consumption outlets for the known rubber-like materials.

Rubbers or Plastics? We have been living within self-imposed boundaries of natural and synthetic rubber terminology. Who can determine the poundage of elastomeric vinyls or polyethylene which is being used today in coatings for fabric or wire and extruded sections and mouldings of all types that would have normally constituted a market for natural or synthetic rubber? As styrenated, cyclized and other after-treated natural rubbers are developed, will they be natural or synthetic rubbers, or will they more properly be called plastics? As polyester resins, "cured" with isocyanates (polyurethanes) or sulfonated polyethylenes overlap on natural and synthetic rubber's markets, will they be catalogued as synthetic rubbers or plastics? The silicone, acrylate, polysulfide rubbers and others are not included in our government and industry statistics of total rubber hydrocarbon consumed today. This problem of proper classification of materials produced by and used in the rubber industry will become more confusing unless we make a concerted industry-wide effort to find a solution in the very near future.

Synthetic rubbers will continue to improve in color and stability, and they will be made more versatile with improved and faster curing techniques. As this transpires, we will see rubbers winning back some of their markets from plastics but, more importantly, developing new markets both in combination with and in competition with plastic materials. There is today a sizable rubber ton-

About the Author

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nage consumed in "plastic" or "non-rubber" outlets. A few of the many examples of this include SBR rubbers blended with high styrene-butadiene resins, NBR (butadiene-acrylonitrile) rubbers blended with styrene-acrylonitrile resins and SBR latices combined with styrene resins to yield high impact molding compounds.

The expansion of rubber into new markets is indicated by the increase of the non-tire rubber segment from 41 percent to 50 percent of the total dollar value of rubber products in the 15-year period from 1939. Recent years have shown this trend to be increasing at an even faster rate.

Large rubber manufacturers are increasing their percentage of non-tire products each year. Although it is true some of this diversification has been in completely non allied fields, the major share has been in the broad field of combinations of elastomers and fibers utilizing increasing amounts of new materials in new end uses.

Cognizance must be taken of this beneficial fusion of the plastic and rubber industries. Rather than try to put up still more boundaries between them in the form of restrictive terminology and incomplete statistical information, there must be a concerted effort to develop encompassing language and statistics to gage properly these changes as they appear and grow.

With the synthetic rubber industry abroad much smaller and newer, foreign countries have been better able to effect a "wedding" of interests in plastics and rubber. This merging of objectives is evident in their journals devoted jointly to technology in the field of rubber and plastics (e.g. *The Rubber and Plastics Age*—London) and the forming of technical societies with common interests (e.g. the French "Syndicat National du Caoutchouc, des Plastiques et des Industries qui s'y Rattachent").

Because of the size and entrenchment of the synthetic rubber and plastics industries in America, the European trend is probably not the solution to this question of properly classifying elastomeric materials and their fields of use. Certainly, however, unambiguous terms, facts and figures must be available. Although a recent proposed revision in the basis for reporting government figures appears to be a step away from this aim, a carefully thought out effort by the American Society of Testing Materials has made an excellent start on a system of nomenclature (ASTM: D1418-56T) for synthetic elastomers produced by and used in the rubber industry.

Growth From New Developments. In addition to the growth which is indicated from statistical trends, advances in rubber developments also foreshadow a healthy future.

Customer benefits from recent developments in SBR (butadiene-styrene) rubbers have included continuing improvement in polymer color and quality, the introduction of new grades and advances in packaging.

Significant advances in fields other than the SBR types have included the evolution of IR (isoprene) rubbers from a test tube development to pilot scale quantities and the industrial adoption of polyurethane rubbers. The IR rubbers have duplicated or bettered natural rubber properties, whereas the polyurethanes have produced low density foams and high abrasion resistant rubbers. Market development efforts on IIR (butyl), opening new outlets to replace those lost with the advent of the tubeless tire has been another noteworthy accomplishment. The combined oil, flame and weather resistant properties of CR rubbers (neoprene) have sparked its continued growth both alone and in combination with other elastomers, bringing it to the position of the second largest synthetic today.

The introduction of the carboxyl groups into NBR rubbers (butadiene-acrylonitrile types) and the development of grades having an acrylonitrile content as high as 50 percent have given these rubbers additional versatility.

Butadiene should continue as the principal monomer for general purpose rubbers. In addition to the prospect for the development of butadiene polymers having properties similar to natural rubber, new butadiene copolymers will be introduced and continued growth is expected of the presently small scale butadiene copolymers such as the acrylates and vinyl pyridine types.

Intensified market developments will expand new volume outlets such as wheels for trains and subway cars, air springs for automobiles and in conveyers and belting for the world of automation. Better highways will expand rubber consumption for trucking, for more passenger car travel and possibly even for rubber in roadway surfacing. The development of collapsible, returnable shipping containers; temporary buildings in the form of air supported structures and the substitution of flexible lines for metal tubing also constitute new outlets for rubber and rubber-like materials. Synthetic rubbers should also find increasing market outlets in the form of latices.

Continued Expansion a Challenge. Synthetic rubbers and allied elastomeric materials are chemicals—the majority petrochemicals, i.e. derived from petroleum raw materials. They are not a commodity, of the nature of natural rubber, which supports brokers with vacillating prices resulting from irregular market demands.

In exchange for a fair selling price for synthetic rubbers, the producing industry can, through research, offer consumers new diverse markets and stable prices which will, in turn, help to stabilize the previously widely fluctuating natural rubber market. Synthetic rubbers can also promise national security through being independent of natural rubber supplies and eventually effect reduction of the huge government-owned natural rubber stockpile.

Because of the nature of synthetic rubbers, capital investment in their production facilities is predominantly owned by petroleum and chemical companies. To compete in the tight market for capital investment and development funds, this new industry must, therefore, match or better the economics realized by the growth products of the chemical, petroleum and plastics industries.

Continued expansion then—through better products and broader markets—is the challenge offered the synthetic rubber industry for the future. In the light of the research expenditures being made and huge capital outlays for expanded production facilities, it might be said that the challenge has been accepted. The goals, which will benefit all industry, can, however, only be met if an adequate return on investment is afforded investors in this growth in industry. ##

a Special Report

Compare Today's Synthetic Rubbers

Here's how all the well known types are made, how they differ and where they perform best.

Harry L. Fisher
Los Angeles

THE FIRST COMMERCIAL synthetic rubber, a polysulfide was presented to the public in 1929, and the first general-purpose synthetic rubber, neoprene (CR), was brought out in 1931. The volumes of these rubbers was very small until World War II and then they rose. In 1939, 1738 long tons of CR type was produced, approximately 700 tons of the polysulfide type, and 1 to 2 of the nitrile rubbers (NBR type). Rubber manufacture executives had stated that their companies manufactured goods of rubber and they would buy any good rubber, natural or synthetic. The war startled the manufacturers and they were very happy indeed when SBR began rolling out of the new Institute, W. Va., synthetic rubber plant in December, 1943. In 1945 the total production of SBR was 719,404 long tons and 45,651 long tons of CR, 47,426 of butyl (IIR) rubber, and 7871 of nitrile rubber. Low temperature emulsion polymerization of SBR was accomplished in 1948, and extension of SBR with petroleum oil was done in 1951. Other synthetic rubbers have come upon the market; these and SBR are discussed below.

About the Author

HARRY L. FISHER, past president of the American Chemical Society (1954) received his A.B. degree from Williams College in 1909, his A.M. degree from Columbia University in 1910, his Ph.D. from Williams College in 1912, and an honorary D.Sc. degree in 1953. He started his long and successful career in the rubber industry as a research chemist with B. F. Goodrich Co. in 1919, then in 1926 moved to United States Rubber Co. as a research chemist. In 1936 he was made director of organic chemical research for U. S. Industrial Chemicals, Inc., and from 1951-1952 spent one year as a research staff member of the Office of Synthetic Rubber in Washington, D. C. After retiring as a director from U.S.I.C., he joined the staff at the University of Southern Canifornia as a professor of chemical engineering and director of the TLARGI Rubber Technology Foundation. He retired for the second time in October, 1956.

Styrene-Butadiene Rubber

The war-time synthetic general-purpose rubber was called GR-S, which stood for Government Rubber-Styrene. It is now manufactured by private companies which have given their products special names, followed by numbers in accordance with the A.S.T.M. designations D1418-56T, D1419-56T and D1420-56T.

SBR has the general composition of styrene-butadiene polymer which was developed and then manufactured in Germany during the late 1930's. The method of manufacture is the emulsion polymerization of about 78 parts of butadiene and 22 parts of styrene, and is somewhat like that used by the Germans but gives softer and more readily millable rubber than the old German SBR. The regular or hot SBR was manufactured by the action of potassium persulfate and dodecyl mercaptan on the hydrocarbons which were emulsified in the presence of soap and the reaction mixture kept at 122 F. The unreacted butadiene and styrene are recovered and used again. The emulsion system at 41 F. was developed late during the war in Germany and then particularly in this country by using an active easily controllable peroxide, cumene hydroperoxide, and *tert*-dodecyl mercaptan, with a special section consisting of ferrous sulfate, potassium pyrophosphate, and sodium phosphate. The so-called cold rubber thus formed is less viscous than the regular SBR and has other more valuable properties, especially the formation with one of the furnace blacks of a tread having about 10 percent higher resistance to abrasion than the best tread with natural rubber.

The mechanism of the polymerization reaction is considered to depend on free radicals. It is difficult to prove their presence but no other method explains the reaction in a better way. The reaction starts with oxidation of the mercaptan by the persulfate and formation of the mercaptan free radical (RS•) which attaches itself to a

molecule of monomer forming a new free radical ($RSM\cdot$). This continues to attach itself to many molecules of the monomers to make a long chain, and this long chain may then terminate itself by collision with a mercaptan free radical giving (RSM_xH) and leaving a mercaptan free radical to start another polymer molecule, or with some other free radical. The exact course of the free radical reactions varies and is not easy to describe. The rate of growth of a polymer chain, once initiated, is relatively rapid, each molecule probably being formed in a period of the order of seconds or less.

The structure of SBR type of synthetic rubber can be determined by infrared spectrometry which indicates it to be a mixture of three types, that formed at 122 F. having about 59 percent of *trans*-1,4-addition polymer, 21 percent of *cis*-1,4-addition polymer, and 18 percent of 1,2-addition polymer. As the emulsion temperature is lowered to 0 F. the *trans*-form increases to 76 percent, the *cis*-form decreases to 7 percent, and the 1,2-addition polymer remains about the same, 16 percent. The changes are approximately linear and show what happens by the lowering of the temperature. The greatest changes are the increase in the *trans*-forms and decrease in the *cis*-forms. It is of interest to recall that the polymer in natural rubber is in the *cis*-form.

As with natural rubber the molecular weight of SBR type varies with conditions. The molecular weight of natural rubber hydrocarbon may be about 2 million as it comes from the tree but it rapidly decreases in the presence of air. The figures for molecular weight also vary with the method—viscosity, osmotic pressure, ultracentrifuge. The most reliable figures are obtained by the osmotic pressure method, but most of the published figures come from viscosity measurements. All figures are for average molecular weights because no one has obtained a pure polymeric substance with the molecular weight of each molecule the same as that of each other. Average figures vary from a number-average of 92,000 to a viscosity average of 400,000, even up to 1,652,000 for SBR. Alfin catalyst (allyl sodium, sodium isoproxide, and sodium chloride) has given products of viscosity-average 9 million. The intrinsic viscosity of SBR in toluene is usually about 2.09 which corresponds to a viscosity-average molecular weight of 270,000. Number-average (by osmotic pressure) is obtained by dividing the total weight of the polymer by the number of molecules, and the viscosity average is from the formula $\eta = KM^a$, in which η is the intrinsic viscosity, K is a constant, M is molecular weight, and a is approximately 0.67.

The emulsion method is generally stopped with hydroquinone or chiefly a mixture of sodium dimethyldithiocarbamate and sodium polysulfide at a conversion of 65-70 percent. The product is treated with an antioxidant and gives a Mooney shearing viscometer value of about 55. The Mooney value increases with higher conversions and generally was not wanted. However, certain properties are very good, and advantage is taken of them by softening them with petroleum oils. The oil is emulsified and added to the synthetic latex, mixed, and coagulated. Variations in the chemistry of the oils give products with differently desired properties. Ordinarily 25 to 37½ parts of oil to 100 parts of SBR type are used, and sometimes much higher. Oil-extended SBR types process well and have excellent properties. Economically they are worthwhile.

SBR is vulcanized like natural rubber but the propor-

Characteristics of Eleven Types of Synthetic Rubber

TYPE OF RUBBER	RAW MATERIALS	MOLECULAR WEIGHT (Average)	BRITTLE POINT (°F)	TENSILE STRENGTH (psi)	ELONGATION (Percent)
STYRENE-BUTADIENE	28 parts Styrene 78 parts Butadiene	270,000	—50 to —60	3500 to 4000	550
NEOPRENE	Chloroprene	206,000	—40 to —70	3500 to 4000	700
NITRILE	80-60 parts Butadiene 18-40 parts Acrylonitrile	20,000 to 900,000	—50 to —66	2000 to 3600	450 to 600
BUTYL	97 parts Isobutylene 3 parts Isoprene	300,000	—70	2500	650
SILICONE	Methyl Chloride and Silicon	2,800,000	—70 to —130	2000	150 to 225
POLYSULFIDE	Ethylene Dichloride and Sodium Tetrasulfide	4000 to 11,000	—35 to —65	1250	600
POLYURETHANE	Adipic Acid Ester, Glycol and Aromatic Diisocyanate	25,000 to 50,000	—38	5000 to 7000	750
CARBOXYLIC	Butadiene and Acrylonitrile	10,000	—49	11,000	500
POLYACRYLATE ELASTOMERS	Esters of Acrylic Acid	—	—7	2200	500
CHLOROSULFONATED POLYETHYLENE	Chlorine, Sulfuric Acid and Polyethylene	—	—40 to —80	500 to 3500	250 to 450
FLUOROETHYLENE ELASTOMERS	Monochlorotrifluoroethylene and Vinylidiene Chloride	740,000 to 1,000,000	—	2100 to 3500	250 to 450

tion of sulfur is less and accelerators are varied. It can be vulcanized with organic vulcanizing agents and no elemental sulfur. The tensile strength of pure gum compounds is very low, 400 to 600 pounds per square inch, but this is increased to 3500-4000 by the incorporation of the special furnace carbon blacks. Carbon black can be added to make a masterbatch by dispersing the carbon black in water and adding it to the synthetic latex, and coagulating the mixture.

The brittle point of SBR types varies from —50 to —60 F., compared with —70 F. for natural rubber. Specific gravity is 0.93; natural rubber 0.92. Antioxidants are required.

SBR type of synthetic rubber can be used as synthetic latex for producing foamed rubbers as mattresses, pillows, upholstery, and many other products. Dry SBR is used for nearly all types of rubber goods, especially where carbon black can be included.

Synthetic Natural Rubber

Synthetic rubber should stand for just that and yet until two years ago no one had synthesized rubber, that is, the natural rubber hydrocarbon. However, the term rubber early became the name of a type of material, and therefore the term synthetic rubber was considered as justified. Now the natural rubber hydrocarbon has been synthesized and it is necessary to use the long term to show what is meant, namely, synthetic natural rubber hydrocarbon.

The first announcement of this synthesis was by the president of B. F. Goodrich Company in December, 1954, and details of the properties and tests were given by the director of research and development at the meeting of the Division of Rubber Chemistry, American Chemical Society, Philadelphia, in November, 1955. Research men of Goodrich-Gulf Chemicals were involved. According to the contract with K. Ziegler of Germany no public announcement can be made of the method of synthesis. The product is *cis*-polyisoprene and infrared analysis indicates probably less than 1 percent of the *trans*-form. A pilot plant is now producing this product which contains 1½ parts of a mixture of 95 percent soya lecithin and 5 percent of triethanolamine. Its average molecular weight is 248,000. This synthetic natural rubber (IR) has slightly better weathering properties than natural rubber but in general is practically the same in its properties as natural rubber.

The Firestone Tire and Rubber Company has also announced the synthesis of a rubber containing 93.8 percent of *cis*-polyisoprene, with no *trans*-1,4 and 1,2-forms, but some 3,4-addition. Its average molecular weight is 669,000, internal friction is 0.55 kilopoises while that of natural rubber hydrocarbon is 0.6 and of cold SBR type is 1.36. In all types of tires it is about the same as natural rubber, sometimes better. This IR type is prepared by treating 100 parts of highly purified isoprene with 0.1 part of finely divided lithium at 40 C. The catalyst is prepared by being melted under high speed agitation in petroleum jelly at 230 C. in a stainless steel apparatus, not in glass. It is highly pyrophoric and consists of particles of about 20 μ in diameter. A pilot plant is also producing this synthetic natural rubber.

Neoprene

The first account of neoprene (CR type) was given in Akron late in 1931. In the course of the experiments in the Du Pont laboratories there was isolated by Arnold M. Collins 2-chloro-1,3-butadiene which became the starting material for preparing the polymer. The chlorobutadiene was christened chloroprene. The CR type polymer is manufactured by a simple emulsion system consisting of *N* Wood rosin and sulfur dissolved in the chloroprene, the mixture emulsified with sodium hydroxide and the sodium salt of naphthalene sulfonic acid-formaldehyde condensation product with potassium persulfate as the oxidizing agent. When the polymerization is complete an emulsion of tetraethylthiuram disulfide may be added, the mixture aged to allow cleavage of sulfur linkages, then acidified just short of coagulation with acetic acid, and coagulated by freezing on a metal surface, dried, and finally gathered into rope form cut into short lengths for shipment. The specific gravity of the product is 1.23.

The name neoprene covers several CR type polymers depending on the method of polymerization. Letters are added to tell the types. Neoprene rubbers are "sulfur-modified" and "non-sulfur-modified." Types GN, GN-A, and GR-T are sulfur-modified and require only metallic oxides for vulcanization, whereas Types W and WRT are non-sulfur modified and are dependent not only on metallic oxides but also on accelerators to develop proper cures.

The structure of neoprene is over 95 percent, 1,4-addition of chloroprene, $-CH_2-\underset{\displaystyle Cl}{\underset{|}{C}}=CH-CH_2-$, in *trans*-form, and a small proportion of 1,2-addition, $-CH_2-\underset{\displaystyle CH}{\underset{\displaystyle \|}{\underset{\displaystyle CH_2}{\underset{|}{\underset{\displaystyle Cl}{\underset{|}{C}}}}}}-$. Vulcanization involves this small proportion. Under alkaline condition an allylic rearrangement takes place giving $-CH_2-\underset{\displaystyle CH}{\underset{\displaystyle \|}{C}}-$, then the zinc oxide reacts removing the chlorine atom and forming an ether. Thus the molecules are cross linked.

Vulcanization of CR types is done by adding magnesia (4 parts) and zinc oxide (5 parts) and heating the mixture 10 to 30 minutes at 307 F.; other temperatures can be used depending upon the type and composition of the stock. The grade of magnesia is important, only the light or extra light grades of calcined magnesia being required for high stability and maximum protection against deterioration by aging of the vulcanizates. Red lead without magnesia and with zinc oxide gives maximum resistance to swelling by water. Litharge acts like red lead but gives less processing safety and storage stability. Accelerators such as 2-mercaptoimidazoline and the di-ortho-tolylguanidine salt of dicatechol borate are used as accelerators. There are others and wide variations are formed.

CR types can be vulcanized with sulfur but the properties of the vulcanizates are usually not as good as when no sulfur is used. Sulfur-vulcanized stocks are harder, higher in moduli and lower in ultimate elongation, and

with relatively poor tear resistance and heat aging properties.

Antioxidants such as phenyl-α-naphthylamine and phenyl-β-naphthylamine are very useful. Non-staining antioxidants are also used. CR stocks show very good resistance to aging including ozone.

The tensile strength is like that of natural rubber compounds, 3500-4000 pounds per square inch for gum stocks, and 4500-5000 pounds per square inch for carbon black stocks. In the absence of flammable compounding ingredients CR vulcanizates possess flame resistance. Brittle temperatures are —40 to —70 F. depending on the compounding. CR vulcanizates show good resistance to swelling in oils, and certain ones have a low compression set and good resistance to heat.

CR latexes are manufactured in several types and used extensively.

CR rubbers are useful probably in more applications than natural rubber.

Nitrile Rubbers

Nitrile rubber (NBR type) was invented by E. Konrad and E. Tchunke rin Germany in 1930 by copolymerization in an emulsion of butadiene and acrylonitrile. It was called Buna *N* with changes in the number of *N's* depending on the proportion of acrylonitrile used, 18 to 40 percent. The specific gravity varies from 0.96 to 1.00. NBR type rubbers are manufactured by several different companies in the U. S. They swell comparatively little in petroleum oils and in vegetable and animal oils, are heat resistant and resistant to abrasion. Swelling in oils decreases with increase in proportion of acrylonitrile, but the nitrile rubber with high proportion of acrylonitrile is harsher.

The production of NBR rubbers in this country was only 1 to 2 tons in 1939 and about 33,000 long tons in 1956. The price is 50 to 60 cents a pound. Production is comparatively small but the product is very useful.

The NBR rubbers are vulcanized with sulfur, accelerator and zinc oxide, using a smaller proportion of sulfur than natural rubber requires because of the lower proportion of unsaturation. Non-sulfur vulcanizing agents are also used, tetramethylthiuram disulfide, and *p*-quinone dioxime. When vulcanized with tetramethylthiuram disulfide NBR rubber may be used in contact with kerosine up to 450 F. Carbon blacks, zinc oxide, and silica are required to obtain the best properties with NBR rubbers. Tensile strengths of 2000 pounds per square inch and elongation of 600 percent are obtained with 30 volumes of zinc oxide, and 3600 pounds per square inch and elongation of 450 percent with the same volume of carbon black. Brittle point is —5 to —66 F.

NBR rubbers are incompatible with natural rubber but if carbon black is mixed first in each then they blend very well. Blends with SBR types are easily made, also with polysulfide types.

About one-third of the production of NBR rubbers is distributed as latexes.

Butyl Rubber

Butyl rubber (IIR type) is the cheapest synthetic rubber, priced at 23 cents a pound. It was invented by W. J. Sparks and R. M. Thomas of the Esso Research Laboratories in 1937, but not produced commercially until 1943. It is a hydrocarbon copolymer formed of about 97 parts of isobutylene and 3 parts of isoprene in the presence of a Friedel-Crafts type of catalyst, aluminum chloride dissolved in methyl chloride, at a very low temperature, —140 F. The reaction is an ionic type of polymerization whereas SBR is prepared by a free-radical reaction.

The low proportion of isoprene makes the IIR type rubber vulcanizable whereas the polyisobutylene itself is not vulcanizable. The units of isoprene are joined chiefly, if not entirely, in the 1,4-addition and in random positions. IIR rubber gives a beautiful x-ray diffraction pattern which indicates a highly developed state of crystallization. Its density is 0.91, and its average viscosity-molecular weight is about 300,000.

IIR rubber can be vulcanized with sulfur and an ultra-accelerator since the unsaturation is low. Tensile strength is about 2500 pounds per square inch and elongation 650 percent and higher for a pure gum type, and about the same when reinforced with carbon black. It is soft and mills very quickly. It can be stiffened by heating with 0.1 part of *p*-dinitrosobenzene, which is a vulcanizing agent. Also it can be vulcanized with a *p*-quinone dioxime and lead dioxide, which make a somewhat scorchy mixture.

IIR rubber has rather high resistance to ozone although it finally suffers some attack. Toward nitric acid (70 percent), sulfuric acid (50 percent), concentrated hydrochloric acid, and phosphoric acid (85 percent), it stands up well. Swelling is only about 10 percent in animal and vegetable oils, acetone, and esters, and much higher in aromatic hydrocarbons and still higher in aliphatic hydrocarbons.

Tear resistance is high, close to that of natural rubber; brittle point is low, —70 F., but the rubber is sluggish between 100 and —30 F.; resilience is low at room temperature but like natural rubber at 212 F.; electrical properties are excellent.

IIR rubber has a low permeability to gases and therefore has found extensive use in inner tubes; even as lining in some tubeless tires. IIR is also used in tire curing bags. *p*-Aminophenol is a good non-staining antioxidant and now IIR is found in different colors in automobile window trim.

IIR has not been converted into hard rubber, evidently because of its low unsaturation.

Milling IIR rubber and carbon black on a hot mill in cycles and also by stretching the mixture increases the modulus and the tensile strength. Tires made of this mixture stop more quickly than natural rubber tires on both wet and dry pavement, they do not "squeal" on rounding corners, and withstand weathering well, and are just becoming available commercially.

IIR rubber does not make satisfactory blends with natural rubber and with SBR type, but does with CR types.

An IIR rubber latex has only recently been manufactured and is used in bonding IIR with tire cord.

Brominated IIR is an excellent adhesive for attaching rubbers to metal.

The production of IIR rubber in 1955 was 55,291 long tons.

Silicone Rubber

Silicone rubber has a chain of silicon and oxygen atoms in alternate positions and therefore it is different from

nearly all the other synthetic rubbers which chiefly have chains of carbon atoms. In standard silicone rubber each atom of silicon carries two methyl groups. Silicone rubber has a remarkable extension of its rubberlike qualities over an unusually wide range of temperatures, from about —70 to +500 F., and when 7 percent of the methyl groups are replaced by phenyl groups, the range is greater, from —130 to +600 F. No other rubber can duplicate this performance although two, polyacrylate and fluoroethylene elastomer, do go up to 400 F. but not near the lower point.

The chemistry of the preparation of silicone rubber is rather simple. Methyl chloride and silicon at about 300 F. over a catalyst form dimethyldichlorosilane which is isolated, and hydrolyzed. The hydroxyl groups react with each other, giving off water and forming a very long chain. The diphenyldichlorosilane is prepared by a Grignard reaction on a large scale.

Carbon black gives little, if any, reinforcement; alumina, titanium dioxide, and finely divided silica reinforce silicone rubbers, giving tensile strength up to 2000 pounds per square inch, where ordinarily only 300 to 600 pounds per square inch and elongation of 150 to 225 percent are obtained. Benzoyl peroxide is the usual vulcanizing agent. Mixtures are heated in molds for a few minutes at 307 F., removed, and set in an oven for many hours.

Silicone rubbers are also manufactured with a small proportion of unsaturated groups, such as vinyl, and these products are vulcanized with sulfur.

Silicone rubbers can be colored since the crude material is only a buff color. Shore *A* hardness varies from 40 to 85. They are waterproof and water repellent. The adhesion of ice to silicone rubber is very poor. Electrical properties are good. Silicone rubbers will burn and support combustion. They show good resistance to swelling in oils, and are odorless, tasteless, and nontoxic. The molecular weight is high, up to 2,800,000 in a fraction. Ozone does not attack silicone rubber and the rubber shows excellent weathering.

Polysulfide Rubbers

Polysulfide rubber was the first commercial synthetic rubber and was marketed in 1929. It was the first synthetic rubber prepared without a carbon-carbon chain and with no unsaturation. Ethylene dichloride was reacted with sodium tetrasulfide forming $(—CH_2—CH_2—S_4—)_n$. The four atoms of sulfur are probably all in a straight chain. The rubber has remarkably low resistance to swelling in oils, solvents and greases. Unfortunately it has a bad odor which has prevented its use in some cases.

Other dichlorides can also be used and two of the modern polysulfide rubbers are prepared from bis (2-chloroethyl) ether, $ClCH_2CH_2OCH_2CH_2Cl$, and from di-2-chloroethyl formal, $ClCH_2CH_2OCH_2OCH_2CH_2Cl$. 1,3-Glycerol dichlorohydrin, $ClCH_2CH(OH)CH_2Cl$, is also used. They have improved odors. Treatment of the polymers with alkali removes 2 of the 4 atoms of sulfur in each S_4-group, and then the earliest polysulfide rubber is no longer rubbery, whereas the others are rubbery. Addition of sulfur brings back the rubber properties. The chains do not terminate in —SH groups but probably in —OH groups by hydrolysis of Cl.

The polysulfide rubbers are vulcanized by heating them with moist zinc oxide. Tensile strengths reach only up to about 1250 pounds per square inch and elongation of about 600 percent.

Polysulfide rubbers have very high resistance to swelling in oils and solvents, and to gas permeability. They are not affected by ozone and therefore show very good aging properties. These rubbers are serviceable from —35 to +300 F., and in certain cases from —65 to +350 F. They are used chiefly where their resistance to swelling in oils and gasoline is paramount.

Reduction with sodium hydrosulfide and sodium sulfite gives short chains ending with —SH groups, with average molecular weights of 4000 to 1000. These liquid polysulfides are oxidized in the air or with peroxides to give high molecular weight products with characteristic polysulfide rubber properties.

Polyurethane Rubbers

The polyurethane rubbers have several wonderful advantages which indicate an unusual future for them. They were started in Germany during World War II and now are also manufactured in the U. S. They show high tensile strength of pure gum products, 5000 to 7000 pounds per square inch, with good elongation of 750 percent, twice the abrasion resistance of natural rubber tread, and higher tear resistance than natural rubber. They can be vulcanized with a very low proportion of water and the reaction produces carbon dioxide which gives high porosity in foamed products. Small solid tires can be cast but regular automobile tires have not yet been manufactured economically. However, tires with polyurethane treads have shown mileage of over 50,000 and up almost to 100,000 miles.

Some other properties of polyurethane rubbers are as follows: They show no attack by ozone and therefore weather excellently. They are fire resistant, produce a distinct x-ray diffraction pattern, have rebound similar to natural rubber both cold and hot, swell very lowly in hydrocarbons, and have lower internal friction than natural rubber and give out less heat on deformation. They have a rather high brittle point, —38 F., specific gravity 1.17, Mooney shearing viscometer 50-100, intrinsic viscosity (η) 1.0-2.0, molecular weight 25,000-50,000, and are soluble in ketones, esters and chlorinated hydrocarbons. Polyurethane rubbers age poorly in hot water and are decomposed by strong acids.

The polyurethane rubbers are prepared by a theoretical excess of first making an ester of adipic acid and a mixture of ethylene and propylene glycols to leave free hydroxyl groups on the ends, and then the free hydroxyl groups are reacted with an aromatic diisocyanate in excess which forms urethane groups, whence the name, and extending the chains. Vulcanization is done by treatment with more diisocyanate or a glycol, diamine or amino alcohol, to form cross links. As mentioned above water may be used which forms urea derivatives and carbon dioxide.

Several diisocyanates are available at present, and their lower prices and availability will increase the interest in and production of these rubbers. The cheapest is a mixture of 80 percent tolylene 2,4-diisocyanate and 20 percent tolyl 2,6-diisocyanate.

One polyurethane rubber starts with a polyether with

free hydroxyl groups. Tire treads made of it require carbon black. Carbon black reduces the properties of the other polyurethanes.

Carboxylic Rubber

Carboxylic rubber contains a very low proportion of free carboxyl groups on the polymer chain. They are prepared by the copolymerization of butadiene and acrylic acid or its derivatives, and acrylonitrile may be included in the chain. The acid rubbers are good adhesives for attaching rubber to metal. Particularly they can be vulcanized with zinc oxide alone or with sulfur. Vulcanizates with zinc oxide give very high tensile strength, up to 11,100 pounds per square inch, which is the highest figure recorded for a rubber product. Zinc oxide simply forms salts with the carboxyl groups and thus cross links the rubber molecules.

Carbon black does not increase the tensile strength but acts only as a loading agent. Resistance to ozone is good with zinc oxide cures and they give low figures in the DeMattia flex cracking test.

Latexes are formed and are of possible use in the paper, leather, and textile industries.

Polyacrylate Elastomers

The polyacrylate elastomers or rubbers are simple polymers of esters of acrylic acid. Usually only the methyl and ethyl esters are employed since the higher alkyl esters give soft and sticky polymers. However, 1,1-dihydroperfluorobutyl acrylate forms a polymer which is expensive but is non-swellable in nearly all oils, solvents and greases, and is serviceable in oils up to 400 F.

The polyacrylates are not as snappy as natural rubber and they return slowly when the stress is released. They are prepared by emulsion polymerization in about 3 hours, at atmospheric pressure, 90 percent conversion.

They are vulcanized with many different types of agents, benzoyl peroxide, quinone dioxime and red lead, sodium metasilicate pentahydrate, and others. Cured 45 minutes at 310 F.

Tensile strength of carbon black compounds is up to 2200 pounds per square inch and elongation is 500 percent. The brittle point is high, —7 F., and they have an affinity for water.

The polyacrylates withstand the deteriorating effects of high temperature, up to 400 F, in air and various nonaqueous immersion media, show resistance to flexural breakdown, compression set, ultraviolet light, ozone, mineral oils, and gas diffusion. They have good electrical properties.

They are of use in O-rings, grommets, hose, transmission and conveyor belts, valve seats, oil seals, and other mechanical goods that come into contact with oils and high operating temperatures.

Chlorosulfonated Polyethylene

Ozone is the great destroyer of natural rubber products but it never shows any action on chlorosulfonated polyethylene. O-rings and gaskets of it are used in ozone generators.

This polymer is prepared by the action of chlorine in the presence of sulfur dioxide on polyethylene. Polyethylene is a plastic but the substituted chlorine separates the chains and allows proper movement for elasticity. The product contains about 29 percent of chlorine and about 1.25 percent of sulfur which is in sulfonyl chloride groups. There is approximately one atom of chlorine for every 6 atoms of carbon and one sulfonyl chloride group for about every 100 carbon atoms.

Vulcanization is done with magnesia and the moisture formed by the action of magnesia on the hydrogenated wood rosin in the product at the temperature of vulcanization, 280-307 F. The sulfonyl chloride group is hydrolyzed by the moisture and magnesia forms salts with the sulfonic acid groups to give cross links. Addition of a thiazole accelerator is important. Other agents are also used.

The polymer is white and any color can be added. Carbon black shows no reinforcement. The vulcanizates have fair to good oil resistance, outstanding heat resistance up to 300 F., very good abrasion resistance, high flex resistance, and excellent resistance to strong chemicals. Tubes of the material carry concentrated sulfuric acid, 50 percent chromic acid, hydrogen peroxide, calcium hypochlorite, and other strong oxidizing agents. Colored coatings of footballs withstand abrasion and water.

The specific gravity is 1.1. Tensile strengths vary 500-3500 pounds per square inch and elongations 250-450 percent, modulus at 100 percent 200-2000 pounds per square inch, Shore hardness 45-95, and brittle temperature —40 to —80 F. No antioxidant is used.

Fluoroethylene Elastomers

Fluoroethylene elastomers are manufactured by the addition copolymerization of monochlorotrifluoroethylene, $CFCl=CF_2$, and vinylidene fluoride, $CH_2=CF_2$. It contains more than 50 percent fluorine by weight, and its vulcanizates have an unusual combination of elastomeric properties, chemical resistance, and thermal stability. When compounded with a fluoroethylene resin it withstands red fuming nitric acid during prolonged immersion. Vulcanizates of fluoroethylene elastomers are resistant to fuming sulfuric acid, oxidizing acids, and other chemicals, including ozone, and have low gas permeability, low moisture absorption, non-flammability, high thermal stability up to 400 F., and nontoxicity. They have very low swelling in petroleum based oils, somewhat higher swelling in aromatic hydrocarbons, and high in diester and phosphate ester based lubricating oils.

The unvulcanized material has specific gravity of 1.85, intrinsic viscosity in methyl ethyl ketone 2-3, and average molecular weight 740,000 to 1,000,000. It is translucent and off-white in color.

Fluoroethylene elastomers are vulcanized with benzoyl peroxide, tetraethylene pentamine, and several other agents. It is cured 30 or 15 minutes at 230 or 330 F. in a press, followed by 16 to 5 hours at 300 to 330 F. in an oven, depending on the agent. Tensile strengths are 2100 to 3500 pounds per square inch, elongations 450 to 350 percent, Shore *A* hardness 55 to 65, Gehman stiffness T_{10} 23 to —4 F., and compression set 33 to 22 percent.

These properties make fluoroethylene elastomers useful in safety gloves, boots, garments, fuel cells, nitric acid hose, wire and cable insulation, applications in the food industry since it withstands sterilization temperatures, and in many mechanical goods. ##

a Special Report

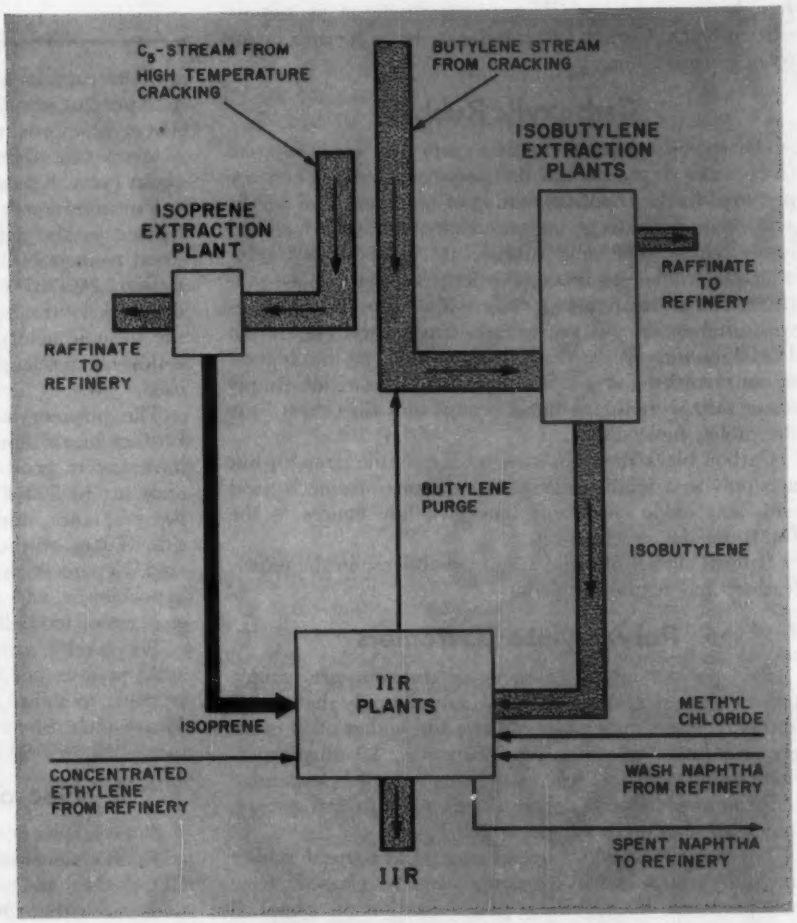

FIGURE 1—Refinery raw materials for IIR type rubber manufacture. Notice that all raw materials are refinery products.

Take a Look at Butyl Rubber

Check these:

- **Production**
- **Application**
- **Properties**

John L. Ernst and E. Arundale
Enjay Laboratories
Linden, New Jersey

BUTYL RUBBER, a versatile synthetic elastomer, represents a second stage conversion of the rapidly growing list of petrochemical raw materials. Polymers of this type are produced (under U. S. 2,356,128 and other U. S. Patents) in two plants in the U. S. and are marketed by the Enjay Company. A plant in Canada operated by the Polymer Corporation is also producing butyl rubber. The capacity of these plants is 116,000 long tons per year. In addition, a new 20,000 ton plant is being built in France. A 30,000 ton-per-year plant to be constructed in the U. S. by Petroleum Chemicals, Inc., has been announced.

Chemically, butyl IIR type is a high molecular weight copolymer of 97-99 percent isobutylene and from 1-3 percent isoprene. The present available production capacity requires approximately 116,000 long tons of isobutylene and 2320 long tons of isoprene per year. These raw materials are derived from thermal and catalytic cracking of liquid hydrocarbons.

Figure 1 shows how efficiently IIR plants tie in with the petrochemical operations in a modern refinery.

The butylene streams are processed through the isobutylene extraction and redistillation units supplying 99+ percent purity isobutylene to the IIR plant with the raffinates returning to other operations in the refinery. A C_5 distillate from high temperature cracking operations is used as feed stock to the isoprene extraction section which

yields isoprene for the IIR plant and returns the raffinate to the refinery for further processing.

Since the IIR process does not operate at 100 percent conversion, the recycle system must be purged of the impurities entering with the feed stocks as these impurities are generally molecular weight poisons for the polymerization reaction. These purge streams can be returned to the extraction units for recycle.

In addition to the basic raw materials, pure ethylene for refrigeration and methyl chloride are required. The only material purchased outside the refinery is the diluent methyl chloride which is recycled through a purification system and requires only sufficient addition to make up the losses through valve and pump leakage.

PRODUCTION

Production of IIR represents a major engineering achievement since the reaction between the two monomers takes place practically instantaneously at a temperature in the neighborhood of—140 F. As shown in Figure 2, the feed is cooled to about —140 F and fed continuously to the polymerization reactors. At the same time, a Friedel-Crafts catalyst in methyl chloride solution is continuously injected into the reactors.

Liquid ethylene, at its boiling point, is circulated through cooling coils to remove the heat of reaction. The temperature is thus kept at about —140 F. As polymerization occurs, a slurry of very small rubber particles forms in the reactor. This slurry overflows into a flash drum containing copious quantities of hot water, where the diluent and unreacted hydrocarbons flash off overhead.

At this point, the antioxidant and zinc stearate are introduced into the polymer. The slurry is then vacuum-stripped to remove hydrocarbons and filtered. The wet crumb is dried in a tunnel drier, extruded, hot milled, and subsequently packaged.

APPLICATIONS

Since production started in 1942, IIR has received increasing recognition as an outstanding material for many applications. IIR is a general purpose polymer and when properly compounded, it possesses a number of inherent advantages over natural rubber, SBR rubbers and certain other synthetic elastomers. The most important of these are:

1. Abrasion Resistance
2. Impermeability to Gases
3. Tear Resistance
4. Heat and Age Resistance
5. Ozone Resistance
6. Chemical and Solvent Resistance
7. Flex Resistance
8. High Electrical Resistivity and Dielectric Strength.

The superior performance characteristics of IIR are governed in large measure by the chemical structure of the parent polymer which is quite different from those of the other synthetic rubbers (Figure 3). The distinctive chemical and physical properties exhibited by IIR rubber can be attributed to the paraffinic nature of the polymer molecules, their low and controlled unsaturation, and the presence of regularly occurring methyl side groups attached to closely-packed linear chains.

Compounding techniques can do much to further enhance the properties of IIR. In most cases, the techniques to be used are dictated by a combination of economics, the mechanical properties desired, and the environmental conditions to be met. A critical selection of the ingredients

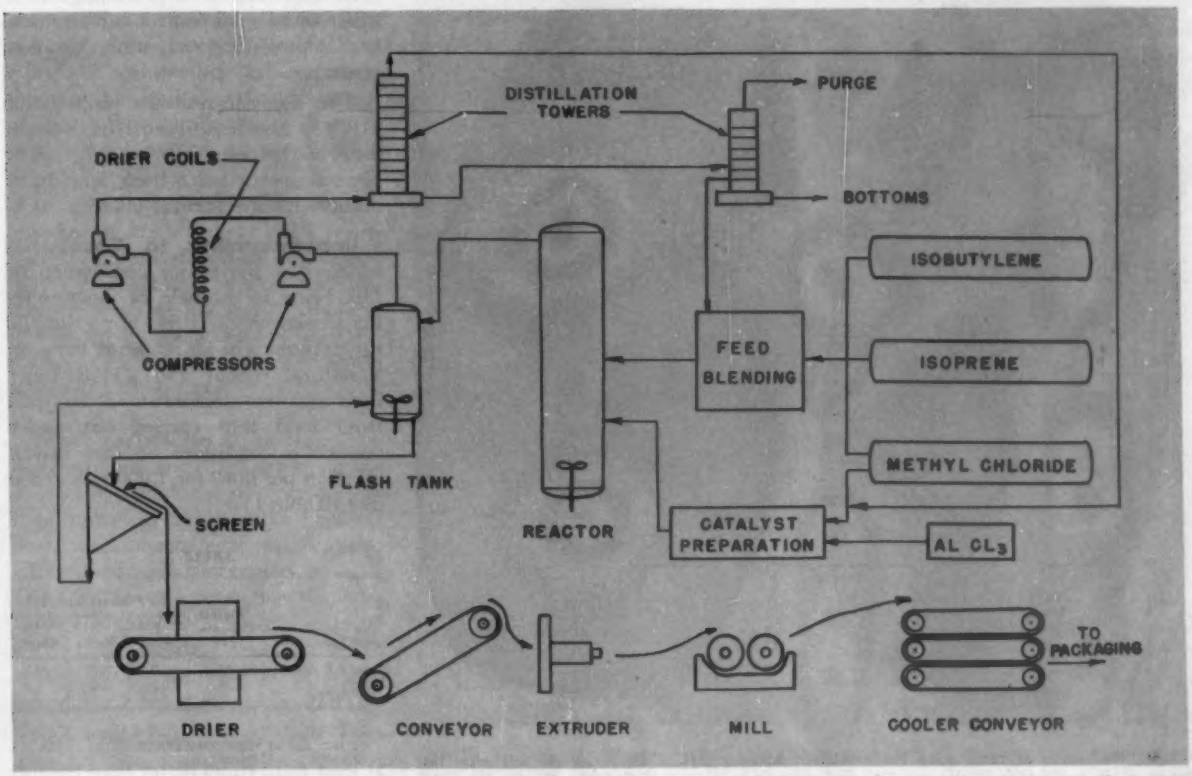

FIGURE 2—This is a schematic flow diagram of the actual manufacturing process for IIR type rubber.

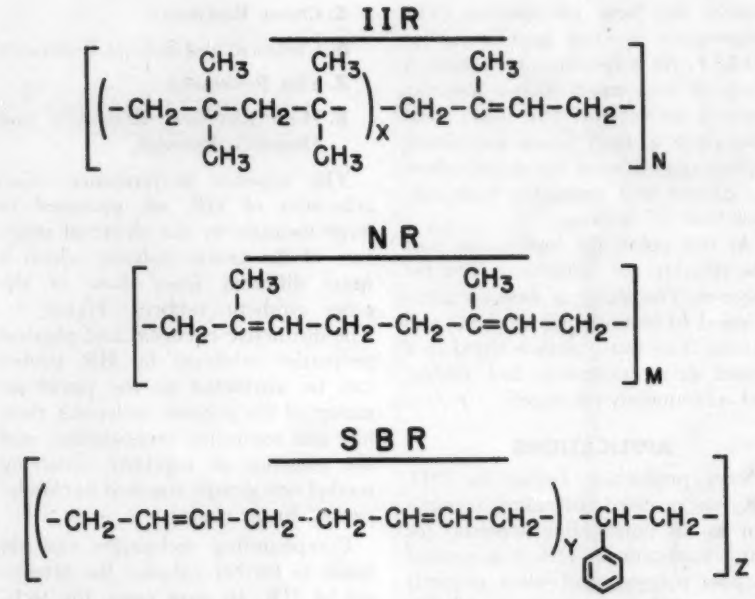

FIGURE 3—Equations showing the chemical structure of the various synthetic rubbers compared to natural rubber. IIR at the top and SBR at the bottom with Natural (NR) in the middle.

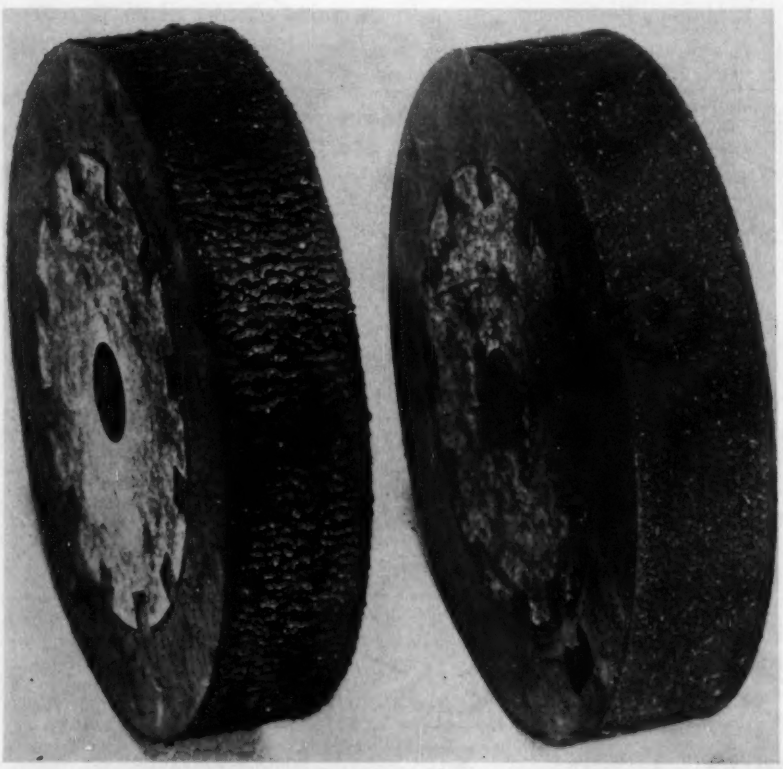

FIGURE 4—Results of tests using the Lambourn Abrader. SBR is shown on the left after test during which percentage of slip was 23.6 and abrasion loss was 0.67 GM/KM. IIR (on the right) shows abrasion loss of 0.29 GM/KM with 19.3 percent slip for similar test.

necessary for vulcanization, reinforcement, plasticization, and processability has, in many cases, permitted the successful use of IIR in applications previously filled by other polymers; and with a marked improvement in certain desired properties.

Abrasion resistance is of importance in many of the large volume uses of rubber, and particularly in tires for automotive equipment. By using the Lambourn Abrader, a concept of abrasion has been developed which fits the performance of a variety of compounds and which brings laboratory results into closer agreement with actual road tests.

Figure 4 shows the difference in abrasion loss between typical SBR and IIR tire treads. The IIR tread is smoother, has operated at less slip, and has shown less abrasive wear than the SBR tread under these conditions. It has been suggested that this somewhat greater friction for IIR treads is responsible for the lack of squeal, quieter riding quality and improved skid resistance of IIR tires.

Figure 5 shows a correlation between laboratory abrasion results and road wear ratings for several IIR rubber tread compounds. Road life has been expressed as a percentage of a SBR commercial control, a high number representing superior abrasion resistance.

The abrasion-resistant property of IIR can also be utilized effectively in footwear, proofed fabrics, solid truck tires, conveyor belts, hose, and many automotive mechanical goods.

Impermeability to Gases has resulted in the major application of IIR being in the field of inner tubes for passenger car tires. For example, the difference in air retention between a natural rubber and a IIR inner tube can be demonstrated by data from road tests carried out under controlled conditions on cars driven 60 miles per hour for 1,000 miles each day (Table 1).

TABLE 1

Inner Tube	Original Pressure, PSI	Air Pressure Loss, PSI		
		1 Week	2 Weeks	1 Month
Natural Rubber...	28	4.0	8.0	16.5
IIR.....	28	0.5	1.0	2.0

The data demonstrate that IIR is at least eight times better than natural rubber in air retention. From a practi-

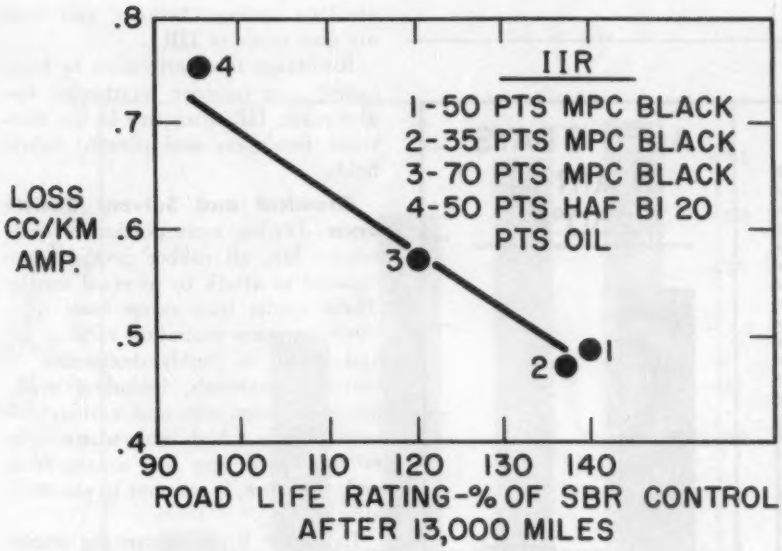

FIGURE 5—A correlation between laboratory abrasion results and road wear ratings for several IIR rubber tread compounds. Road life is expressed as a percentage of SBR commercial control, a high number representing superior abrasion resistance.

cal standpoint, this air holding characteristic permits maintenance of proper tire inflation pressure with a resulting improvement in tread wear and tire life. The increase in tread life attributed to IIR's air holding ability varies between 10 and 18 percent, depending on the test conditions.

IIR rubber is also highly impermeable to a number of other gases (Figure 6) and to moisture vapor. Pure gum IIR compounds are markedly superior to similar vulcanizates of natural rubber and SBR. This superiority holds at all temperatures up to at least 400-450 F.

In addition to its significance in automotive inner tubes, IIR's resistance to air diffusion is of importance in the barriers for tubeless tires, air cushions, and makes it potentially of interest in the manufacture of pneumatic springs for use in the newer model trucks and buses.

Tear resistance after long exposure to air and high temperatures is another property of considerable importance in inner tubes, belting, hose, and mechanical applications. Unaged natural rubber has a somewhat higher tear resistance than unaged IIR rubber (Figure 7). However, after two days of aging in air at 250 F NR lost nearly all of its tear strength while, if anything, IIR becomes somewhat more tear resistant. This has been confirmed by extensive road tests in which nails were driven into fully inflated tires containing new or old IIR inner tubes, and, in either case, no blowout occurred. In fact, the tires were driven for hundreds of miles before they gradually became flat. Although new NR tubes performed similarly, old tubes failed readily, frequently through a blowout.

Heat and Age Resistance of IIR is excellent and directly responsible for its ability to maintain tear strength after extended heating.

NR develops surface hardening, cracking, and forms resinous deterioration products when exposed to elevated temperatures, which condition is more severe in the presence of high sulfur or accelerator combinations. IIR compounds, on the other hand, do not harden on exposure to heat or air; if anything, they tend to become progressively softer while still retaining a high percentage of their original physical properties.

Even at higher temperatures, IIR maintains its superiority over a number of other elastomeric materials. This property of heat resistance is currently of value in tire curing bladders, steam hose, and hot materials belts.

Ozone Resistance—Prior to 1955, the majority of the mechanical rubber parts on passenger cars, trucks, buses, and military vehicles were made from NR, SBR, or, where oil resistance was important, CR or NBR. Within the past few years, exposure cracking of rubber parts on automotive equipment has become a critical problem, particularly in areas where high ozone concentrations are frequently encountered.

Many of the passenger car manufacturers in the U. S. have recognized the inherent ozone resistant properties of IIR and have turned to this polymer as a solution to their problems of weatherability. A number of automotive rubber parts, including window channels, gaskets, body shims,

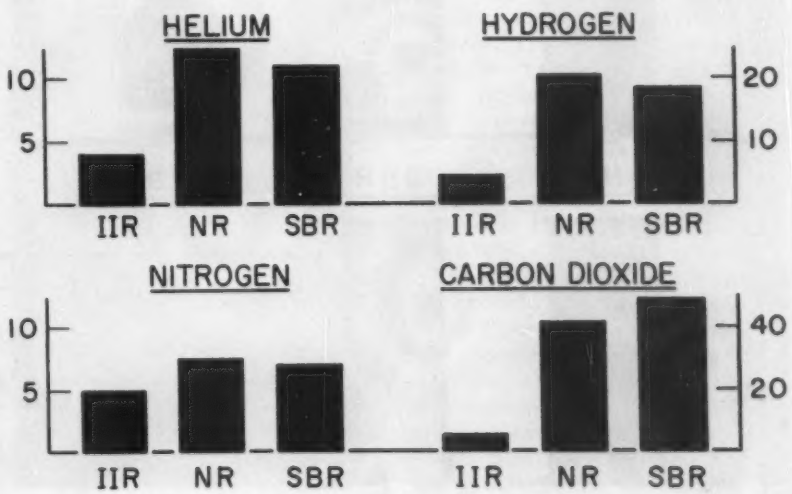

FIGURE 6—Gas permeability in liters per square meter per 10 millimeters thickness per 24 hours for various gases and IIR, NR and SBR type rubbers. Notice the low loss of carbon dioxide by IIR.

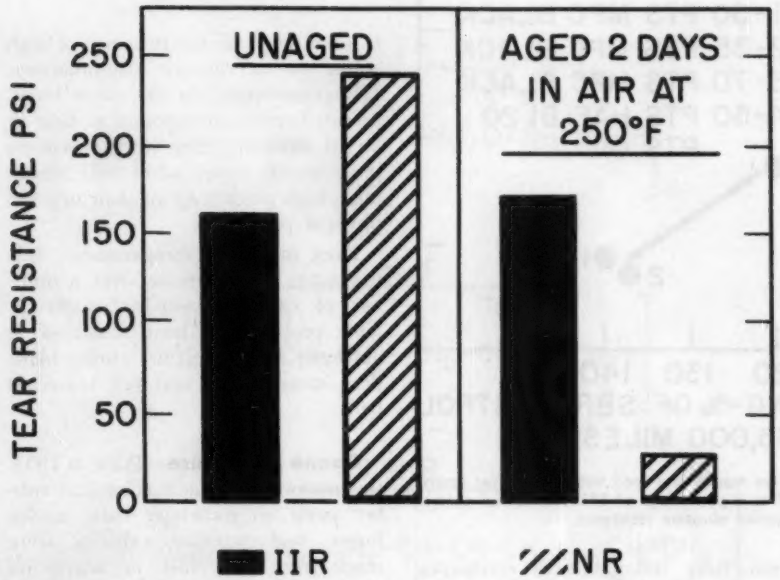

FIGURE 7—Tear resistance for NR and IIR (50 parts SRF Black compounds) at unaged and aged conditions. Notice the superiority of IIR aging.

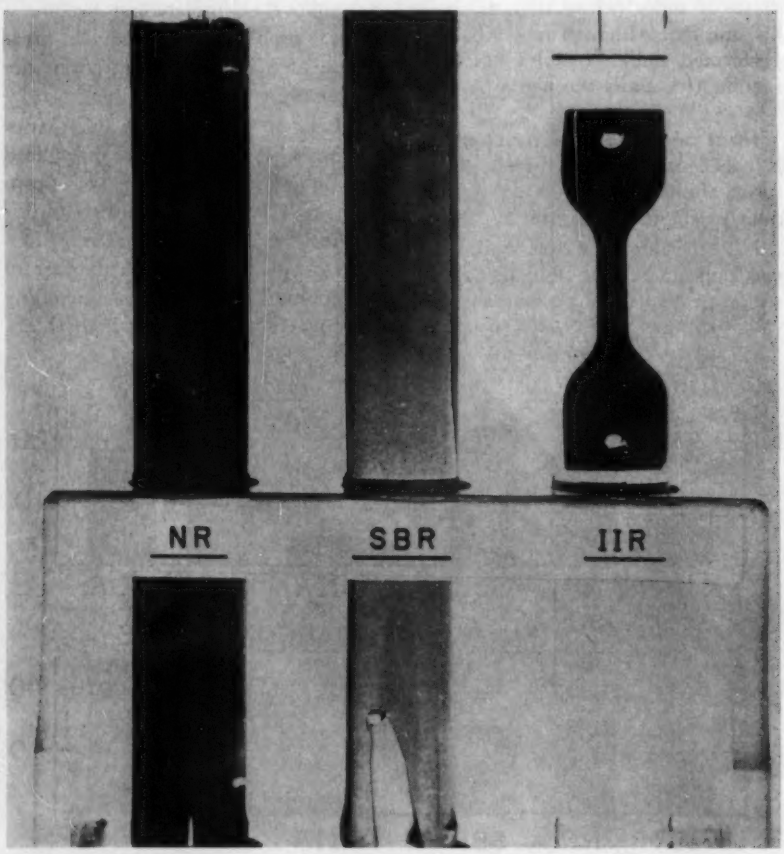

FIGURE 8—Shown here are the results of immersing SBR, NR and IIR in concentrated nitric acid for 24 hours. The NR and SBR have been completely disintegrated while the IIR has not been attacked.

auxiliary springs, bellows, and hose are now made of IIR.

Resistance to deterioration by heat, ozone, and outdoor weathering has also made IIR attractive in the electrical insulation and proofed fabric fields.

Chemical and Solvent Resistance—During some portion of their service life, all rubber products are exposed to attack by external media. These media may range from relatively harmless materials, such as air and water, to highly destructive or corrosive materials, including acids, inorganic salts, oils, and various solvents. IIR is a high molecular weight isoparaffin of very low unsaturation and, therefore, is resistant to chemical attack.

In Figure 8 are shown the results obtained when immersing NR, SBR, and IIR in concentrated nitric acid for 24 hours at room temperature. After this immersion, the NR and SBR have been completely disintegrated, whereas the IIR specimen was not attacked, and retained a high degree of its original strength. This property can be utilized effectively in chemical tank linings, gloves, and protective clothing.

Because of its paraffinic structure, IIR is swollen by aliphatic hydrocarbons or solvents, and thus should not be used in applications involving direct immersion in petroleum fuels or lubricants. However, it does possess excellent resistance to oxygenated compounds, including alcohols, esters, ketones, and the animal and vegetable oils. As shown in Figure 9, it is superior to a number of other polymers in its resistance to the silicate and phosphate types of hydraulic fluids.

IIR is currently being used in many hydraulic applications, in coated fabrics, and in solvent-resistant hose.

Resilience—IIR rubber, like other synthetic elastomers, is not perfect in all respects. In the normal vulcanized condition, it appears to be lacking in flexibility and rebound, particularly at room temperature. This can be improved considerably through the use of selected plasticizers and compounding techniques. At higher temperatures (around 200 F), IIR is quite resilient and comparable in this respect to NR. The dampening property of IIR (Figure 10) can be used to good advantage in vibration eliminators, truck or trailer springs, bumpers, and motor mounts. ##

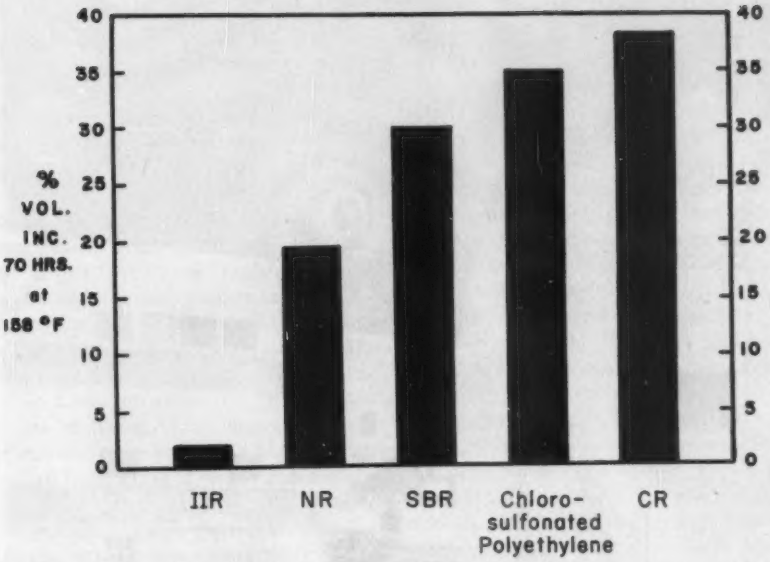

FIGURE 9—This shows the increase in volume (swelling) of various rubbers upon immersion in tricresyl phosphate. Left to right, IIR, NR, SBR, Chlorosulfonated Polyethylene, and CR. IIR shows the best resistance to swelling.

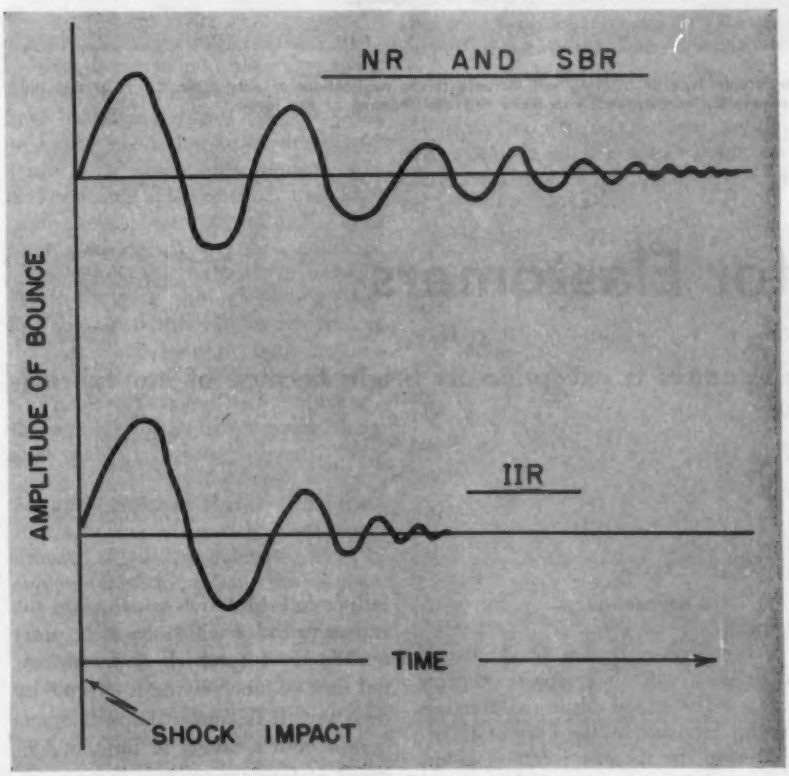

FIGURE 10—Shock absorption diagram for butyl rubber (IIR) and styrene-butadiene rubber (SBR) showing the dampening effect of each type. Notice how rapidly the shock is dampened by the butyl rubber (bottom) as compared to the styrene-butadiene rubber (top).

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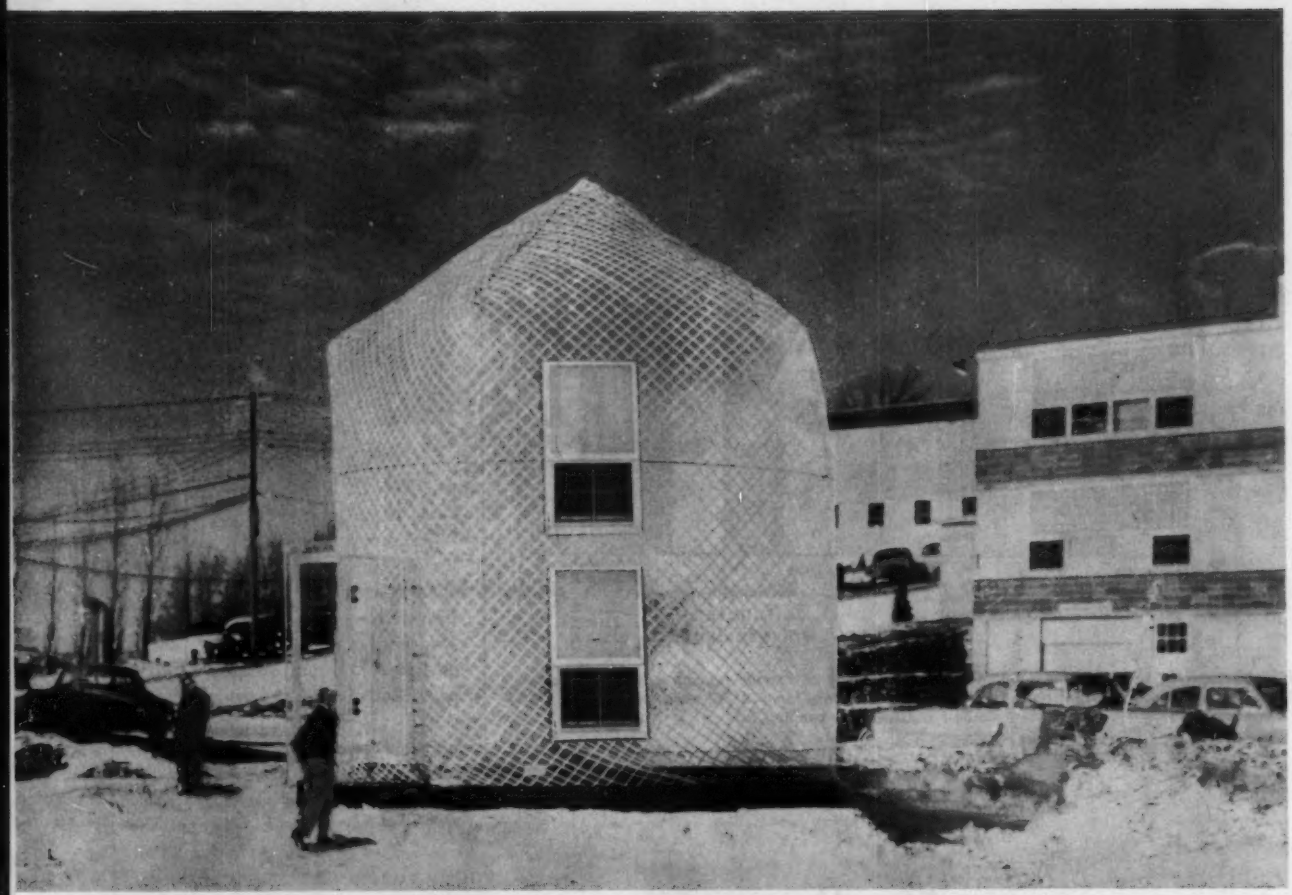


FIGURE 1—Already proved in actual use, this inflatable type of building will increase future applications of elastomers. Low cost materials, simple erection and extremely low maintenance can make this the "housing of the future."

a Special Report

Future Fields for Elastomers

The outlook for elastomers is exceptionally bright because of low fabrication costs.

Johan Bjorksten
Bjorksten Research Laboratories
Houston

THE FUTURE of elastomers may well be based on applications unheard of today. Some of these uncommon or unheard of uses loom on the present horizons of our technology. Others are even farther in the future. However, all of the applications which are mentioned have at least some foundation in fact and a possibility of becoming new and substantial uses for elastomers.

As technology continues to prosper, labor costs will always be on the increase. The broad historical trend is for an increase in the cost of labor.

Due to the increased cost of labor, the trend in materials will be toward a saving in labor, or toward a saving in weight and/or a saving in time of fabrication. Materials which seem too expensive today will be entirely practical in the future, wherever substantial time or labor saving is effected by their use. It is known that elastomers permit both a saving in time, and in speed of fabrication, in a large number of operations. Their increased use in the future is therefore assured.

Where's the Boundary? The boundary line between plastics and elastomers is somewhat hazy. Materials near this boundary line may soon come into the forefront of the advancing technology. Some of these have long been neglected both by elastomer and by plastic technologists, and therefore may present good opportunities for accomplishment.

In the entire field of reinforced plastics, glass has been the principal reinforcing medium. However, from the standpoint of highest impact strength, reduced surface abrasion, high surface finish, synthetic fibers offer great advantages, particularly the polyesters and acrylics and nylon.

In order to attain the full advantages of these fibers, however, they should be used with plasto-elastomers, which have a rate of elongation matching those of the fibers, so that fiber and plastic reach their elastic limits at the same degree of stretch.

The recent development by Du Pont of elastomeric nylon fibers which at the point of maximum stretch have substantially the same tensile strength as conventional nylon, has greatly broadened the potential field of reinforced elastomers. With reinforcing fibers now available to match the elasticity of most elastomers, the strength and tear resistance properties potentially available in elastomers have increased greatly. A whole series of investigations has to be completed before this potentiality becomes a reality. The adhesion of the high strength elastomeric fibers to the continuous phase of elastomer must be made perfect and maintained throughout the stresses and cycles involved. For elastomers this will be much more difficult to accomplish than for low elasticity materials, since the adhesion will have to be completely maintained through a wide range of stress conditions.

Broader Field in Sight. The advent of elastomers of greatly increased strength, should broaden the field of application of the safety glass concept. Certainly, there are materials other than glass, which form sharp jagged cutting edges in case of a collision, for example, light gage metals.

It might thus be entirely advisable, in the interest of public safety, to laminate sheet metal, and certainly all splinterable wood used in public conveyances, with a safety elastomeric layer, firmly bonded thereto and having sufficient strength to absorb impact, and to prevent jagged edges or splinters from forming in the case of destructive impact. As such protective layer, we may well consider a nylon based elastomer, fiber reinforced.

Means for non-destructive inspection will have to be developed which do not depend on ultrasonics. Ultrasonics tend to have insufficient precision for flaw detection in the sound dampening media of the elastomers. It seems that the most efficient means for flaw inspection in reinforced elastomers will be based on thermal conductivity. The speed with which heat travels through the boundary line between two substances is dependent on the intimacy of their contact. Thus, the quality of adhesion should be measurable when we have means for measuring the speed of heat penetration with an accuracy of a few microseconds. Means for such high speed heat determination have recently been developed and are thus available, although the applicability to the aforementioned problems has not yet been shown.

Elastomeric Walls. In the building industry, the advent of elastomeric wall panels of truly high strength, yet lightness and high insulating qualities, would open attractive vistas. From the standpoint of the building operation, any mistakes made by builders could be corrected by using these panels. For example, when a wall section was made too short it could be stretched or twisted to give a close tight fit. A sandwich of an elastomeric foam between two reinforced elastomeric skins could match heat insulation properties with anything in existence. In a playroom, bouncing walls would have great and obvious advantages.

These advantages would be most apparent in pressure supported buildings. The low cost shelter of the future will be the air pressure supported building. Pressure of even one-third pound per square inch will support a load of 48 pounds per square foot. This air pressure can be supplied by a very small blower, which replaces tons of steel and concrete normally required for support.

For best fatigue resistance, a moderately elastomeric skin material might be preferable. This has been considered in design of some of the film materials offered for this purpose. For insulating air supported buildings, however, the use of elastomers becomes mandatory, as only an elastomeric foam would have the necessary adaptability to follow the changes in tension or stress distribution which can occur in a building of an air pressure supported flexible material.

Furniture Possibilities. The furniture industry can be used to great advantage the truly strong and resilient material's in the design of furniture which follows the movements of the body in compound curvature fashion. This will be less expensive

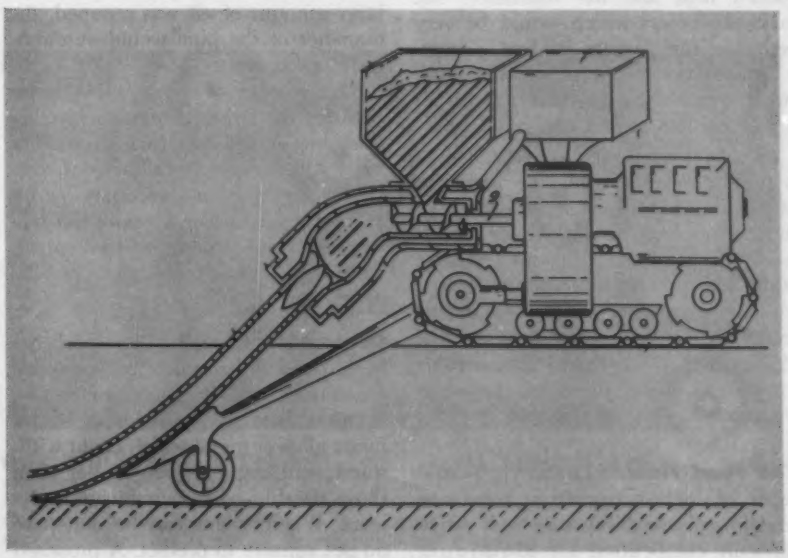


FIGURE 2—This futuristic machine will form and lay continuous lengths of seamless plastic pipe. Joints will be completely eliminated except at the terminals. Maintenance and corrosion problems will vanish as pumping costs become lower and product contamination is forgotten.

therefore will not deteriorate on

and probably more satisfactorily attained by molecular engineering to give the desired yield and elasticity of structural members, than by the mechanical engineering devices now largely depended upon for these purposes.

Problems of flammability will become increasingly important as the reinforced elastomers gain increasing acceptance in building industry. These problems may be attacked either in the conventional way, by incorporation flame extinguishing substances, or by formulation of non-flammable elastomers. These in turn may be based on halogenated substances or may be elastomers based, for example, on phosphorus and nitrogen. To the author's knowledge, no one has yet succeeded in obtaining phosphorus polymers of really good mechanical properties, though sufficient improvements have been made to indicate that this approach is capable of leading at least to non-flammable products on a par with the factices made from sulfurized drying or semi-drying oil.

The most promising lead to non-flammability in elastomers, is probably in the fluorinated compounds. If it were possible to replace the hydrogen atoms in a conventional elastomer molecule with fluorine, without disturbing the carbon skeleton, it should be possible to attain substances which not only would be elastomers of superior heat and fire resistance, but also elastomers which would be very suitable for gaskets in fuel pumps, turbines and other gasket applications, where resistance to fuels or oils at high temperatures is necessary.

This oil or lubricant resistance at temperatures of 500 F and higher is a requirement which is receiving ever increasing emphasis. An approach which covers a useful intermediate zone, exists in some of the acrylates. A silicone content of 2 percent or less can impart temperature resistance of more than 100 degrees and solvent resistance above those of the same compounds without silicones.

The Food Field. Elastomeric plastic films of high temperature resistance and low permeability may well prove difficult competition for aluminum foil in the food field. They would drape better around the food to be protected, and would be free from the tendency to form pinholes at creases or points of sharp bends.

A particularly interesting application for the oil industry lies in the application of reinforced elastic tubing as extrudable piping. As we know, joints are the weak points of any pipe line. Likewise, the task of joining separate lengths of pipe is responsible for a good deal of the time required for building pipe lines. Recently a patent was issued for laying a continuous plastic pipe line by a pipe extruding machine mounted on a tractor. In this fashion it should be possible to lay any length of pipe without joints. However, the plastic pipe thus produced will not carry the pressures of a steel pipe, and therefore does not meet existing pipe line specifications. This has held back the development in spite of the great speed and ease with which a joint-free pipe carrying lower pressures could be laid by this method.

If a reinforced elastomeric pipe could be laid in this manner, it might be made self-pumping in the same sense as the human arteries. The pump would create a "pulse wave" which would be propagated through the resilient pipe. Instead of having very high pressures in a pipe of fixed diameter, we would have a pipe which pulsates, providing larger diameter when a pumpstroke injected a larger amount of oil. This pulse wave would flow through the pipe, and when a large amount of oil was pumped, the diameter of the pipe would automatically increase.

This may or may not prove practical for the large permanent installation, but it should prove a priceless boon where rapid installation of temporary lines becomes necessary, as for example when a canal ceases to function, as feed lines, or particularly where the corrosion is high as in tidal zones.

Elastomeric Glass? Much work has been devoted to study of inorganic elastomers, and it would, of course, be most attractive to have an elastomeric glass or metal which could withstand temperatures even higher than those useable with the silicone polymers. Whether this can be done, we do not venture to predict. A proposed program to conduct pioneering research in this direction was rejected as "too fantastic" even by a government source which generally is not inclined to be deterred by the difficulties.

As the building industry places increasing reliance on panels, the task of joining these becomes an ever more important and exacting task. Expansion areas between panels require new and improved means for joining. These are provided by liquids, which on extrusion harden to elastomeric compositions. These may be applied by caulking guns in cracks or at joints, and may be used for joining panels in such manner, that the joint is permanent and expands and contracts with the requirements of the weather and of the structure which it bonds. Such compounds have already been developed, and are beginning to gain increased acceptance.

The inclusion of foaming agents in such caulking compounds may make possible expansion after application. This in turn may lead to their use on a much larger scale than at present, not only reducing costs by a large factor, but also making it practical to fill completely much larger cracks or openings in building structures, than those which may be tolerated today. This again may reduce the requirements on precision in workmanship, and thus may save time and labor. In these caulking guns, the foaming agent and the vehicle may be applied in different streams, mixed at the orifice to prevent premature foaming and expansion.

The most spectacular single use, however, would be of a very different nature, and governed by the properties of novel materials. As already mentioned, the advent of rip-proof films has reopened the field of pressurized building construction. However, we might as well take the full step. If a structure withstands hurricane wind force and earthquakes on shore, it should also withstand the sea. Therefore, an air pressure supported structure might well be considered as the hull of a sea-going vessel.

Naturally this would upset many concepts, but I am sure that it will deter no one of our readers. Thus, we might envisage a hull, somewhat like that of a blimp, but flattened, and resting on water. The hull is air filled and in it are equipment, crew and passengers. The hull would be made from a fluoroethylene type transparent film, which has virtually no absorption in the ultraviolet range, and

therefore will not deteriorate on weathering. It would be protected from tear by reinforcement, e.g., a criss-cross of continuous fibers, spaced about one-half inch apart, between two films, in an adhesive soft enough to permit slippage of the fibers in case of a beginning tear. Thus, should any tear start, the fibers would slip ahead of it, and would form a rope blocking any further spread of the tear. This principle has been fully proven in practice.

An elastomeric foam sprayed into the inside, would provide efficient insulation. Instead of being gas filled, as the blimp, the hull would be inflated by means of an air compressor, which would maintain an inside pressure of about 4¼ pounds per square inch. This would give a hull resistance of about 600 pounds per square foot, which should be amply sufficient in view of the excellent stress distribution pattern, and the resilience.

About the Author

JOHAN BJORKSTEN is president of Bjorksten Research Laboratories for Industry, Inc., Madison, Wis. The southern regional lab for Bjorksten Laboratories will be open in Houston by May 1. Bjorksten received his Ph.D. degree from the University of Helsingfors, Finland, in 1931; for the next year he was a guest research worker under the auspices of Rockefeller Foundation, University of Minnesota. From 1932 to 1944 he was research chemist, then chief chemist and technical director for several national firms. In 1944 he formed Bjorksten Research Laboratories for Sponsored Industry Research in fields including polymers and elastomers. He holds approximately 60 patents in the field of industrial chemistry.

Connections of gradually tapered modulus would surround all protruding rigid parts, so as to avoid stress concentrations and possibilities of fatigue. The floor structure and machine support would be a base plate of foamed aluminum, resting on the inflated hull inside the inflated area.

Since the hull would be filled with air there would be no need for outside enclosures.

This project might be more realistic than it appears at first glance. The saving in weight would be enormous, and in cost likewise. The limitation as to hydrodynamic shape would be reduced in significance by the fact that the reduced weight would make possible a very small over-all cross-section of the vessel, so that in spite of a less effective hydrodynamic shape, less power would be required to drive it. The vessel would be of a rounded flat shape, with a large supporting surface, and would skim over the waves. The problem of stability would likewise be countered by using a large flat contact area. The reduced weight might also make gyroscopic stabilization more economical. Steering has been shown to be very feasible on shallow draft vessels, by means of a rudder placed in the slip stream of the propeller. The internal air pressure could be reduced at times of landing or loading to the point where a very simple double door air lock would be entirely adequate to permit loading and unloading.

a Special Report

For oil tankers, carrying loads in one direction only, it would be possible to deflate and fold up the tankers on the return trip so as to ship home say nine tankers as cargo on the tenth, thus saving appreciable fuel and operational expense. To make this possible, it may be justifiable to use more compact and possibly somewhat less economical propulsion machinery, or to transport the crude oil in tows of several foldable blimp shaped barges, towed by an atom powered tug.

The stretchability and resilience of the elastomers offer advantages which will increasingly mark the developments in our technology. Controlling stiffness and strength will increase their scope of application.

Following are advantages of Elastomers over more conventional materials:

1. Greater tolerances in machines and structures, reducing precision requirements and thus saving labor.

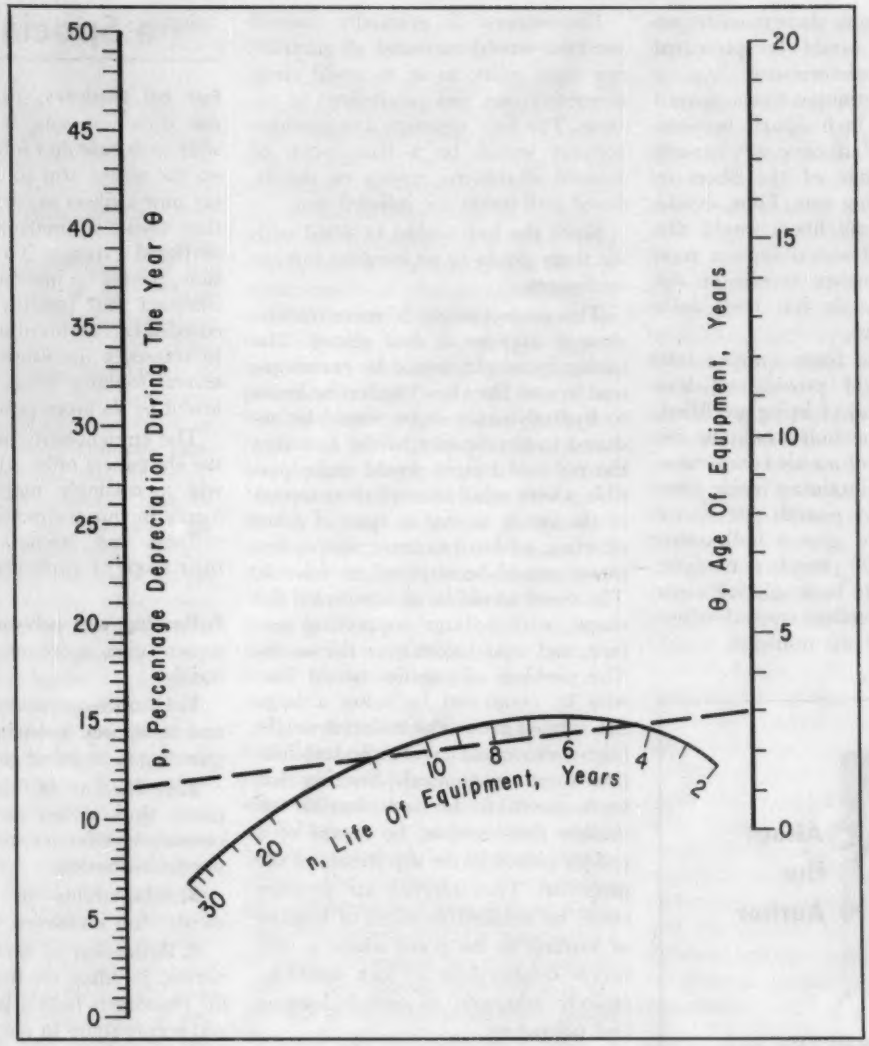
2. Reduction of shocks and impacts, thus saving material and increasing its effective strength by better stress distribution.

3. Adaptability to form requirements, thus increasing versatility.

4. Reduction of noise, thus saving nerves. Building on these advantages, the elastomers hold a large, increasing and secure share in our future. ##

OUR INDUSTRIAL ADVISORS for this SPECIAL REPORT on Synthetic Rubber are shown above, left to right: J. B. D'Ianni, Goodyear Tire and Rubber Company; R. S. Aries, R. S. Aries and Associates; Clayton F. Ruebensaal, Texas-U. S. Chemical Company, and F. Herman Fritz, E. I. du Pont de Nemours & Company, Inc. These experts pointed out important developments and guided us in our search for material included in this issue.*

* The attendance by executives, engineers, superintendents or other employes of oil companies at these conferences does not constitute an endorsement of the REFINER over any other publication. The fact that men of outstanding ability are allowed to attend these planning conferences shows the interest which companies have in sound editorial content for the benefit of the industry.



Find Depreciation Rate by Nomograph

D. S. Davis, University of Alabama, University, Ala.

AT THE FIRST of a given year in the life of a piece of equipment, one can use the sum-of-digits method[2] to compute *P*, the percentage depreciation for that year, by dividing the number of years of remaining life by the sum of the digits that represent the total life and multiplying the quotient by one hundred. Thus, for the second year in the life of a pump that is estimated to last for ten years, the percentage depreciation is $100\frac{9}{1+2+\ldots 9+10}$ or $\frac{900}{55}$ or 16.4.

Consider equipment that is Θ years old and has a total estimated life of n years. The sum of an arithmetic progression where the first term is one and the last term is n is $\frac{n}{2}(1+n)$. P, Θ, and n are then related by the expression $P = 200\frac{(n-\Theta)}{n(1+n)}$

This equation can be solved readily and conveniently by means of the accompanying nomograph, which was constructed through recourse to well-known methods.[1] The use of the chart is illustrated as follows: What percentage allowance for depreciation should be made for the third year in the life of a piece of equipment that is estimated to be serviceable for 12 years? Connect 3 on the Θ-scale and 12 on the n-scale with a straight line. Note the intersection with the p-scale at the desired value, 11.5 percent.

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[1] Davis, D. S., "Nomography and Empirical Equations," Chapter 8, New York, Reinhold Publishing Corporation, 1955.
[2] Hur, J. J., editor, "Chemical Process Economics in Practice," Page 54, New York, Reinhold Publishing Corporation, 1956.

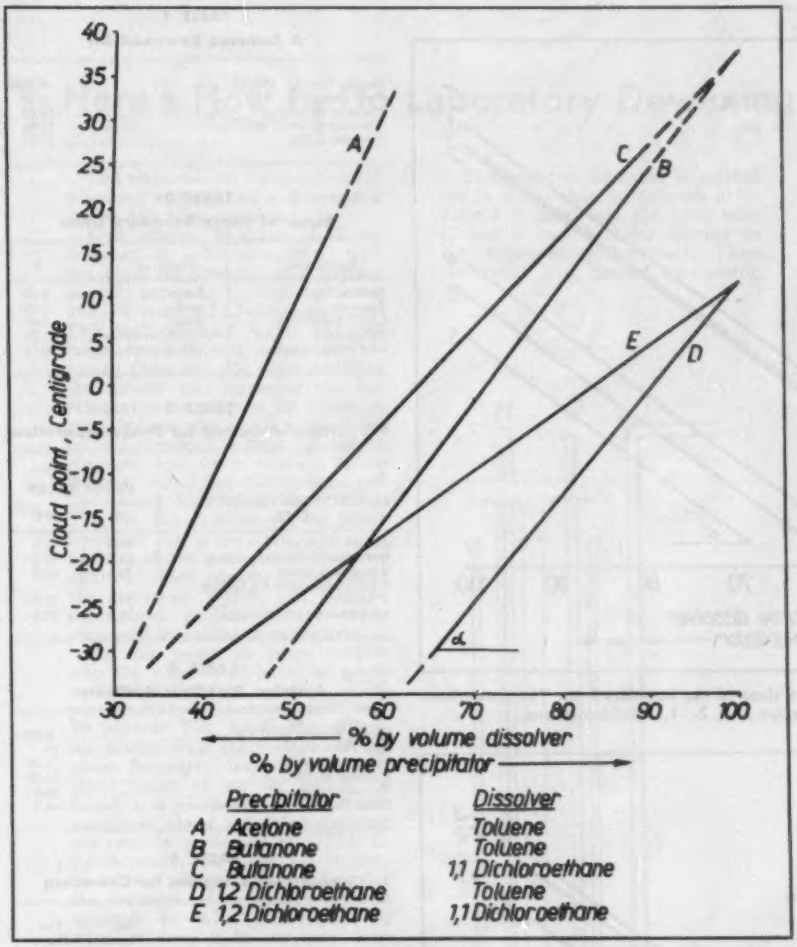


FIGURE 1—The boundary between the one-phase and the two-phase regions is a straight line. Here are the phase boundary lines for different precipitator-dissolver pairs.

Part 1

Examine Solvent Dewaxing

Here is a laboratory study of the factors which influence the dewaxing of mineral oils with solvent mixtures.

R. Rautschka, Vacuum Oil Company
H. Poll and F. Pass, Institute of Technology
Vienna, Austria

THE KIND, QUANTITY, and composition of a solvent mixture and the properties of the oil are significant factors in dewaxing. Of the materials reported here, 1,2-dichloroethane and 1,1-dichloroethane make the most effective precipitator-dissolver pair.

The specifications required for a dewaxing solvent are as follows:

1. The solubility of macro- and microcrystalline waxes must decrease with declining temperature to achieve complete wax precipitation.

2. Paraffin oil components with pour points below the dewaxing temperature must be sufficiently soluble in the solvent so that no oil will be retained by the precipitated wax.

This study of solvent dewaxing is in two parts. The first reports an examination of the effectiveness of various solvent mixtures. The second describes a graphical method for handling dewaxing problems. This information will help you examine dewaxing operations easier and quicker. The second part will appear in an early issue of PETROLEUM REFINER.

Acetone, butanone, higher ketones, and 1,2-dichloroethane are excellent wax precipitators; however, they dissolve mineral oils with a strong paraffinic character at low temperatures, only if the oil has a low average molecular weight. These solvents, therefore, are only suitable for dewaxing light distillates (i.e., heavy gas oil, light spindle oil, etc.). Their solvability is not sufficient for heavier distillates. The oil components are separated together with the solid wax, so that, in spite of washing with those wax precipitators, a complete deoiling is difficult. It is necessary, therefore to add dissolving agents, such as benzene and toluene to these precipitators. They keep the oil in solution, and solvent mixtures are obtained which may be adjusted in their precipitation and dissolving properties to suit the material to be dewaxed. For this reason dewaxing solvent mixtures are used in industrial unit.

The production of dewaxed oils with the lowest possible pour point and an almost completely de-oiled macro- or micro- crystalline wax is difficult from the economic viewpoint. Owing to the great variety of the different base oils and base oil cuts in relation to molecular structure, molecular size and reciprocal

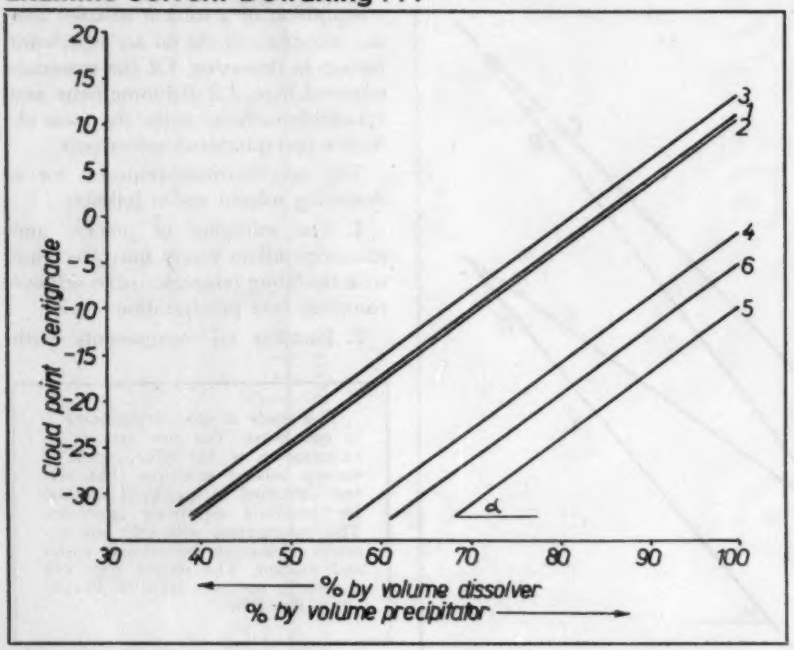


FIGURE 2—The type of oil does not influence the slope of the boundary lines. The data shown here were obtained using a solvent mixture of 1, 2-; 1, 1-dichloroethane.

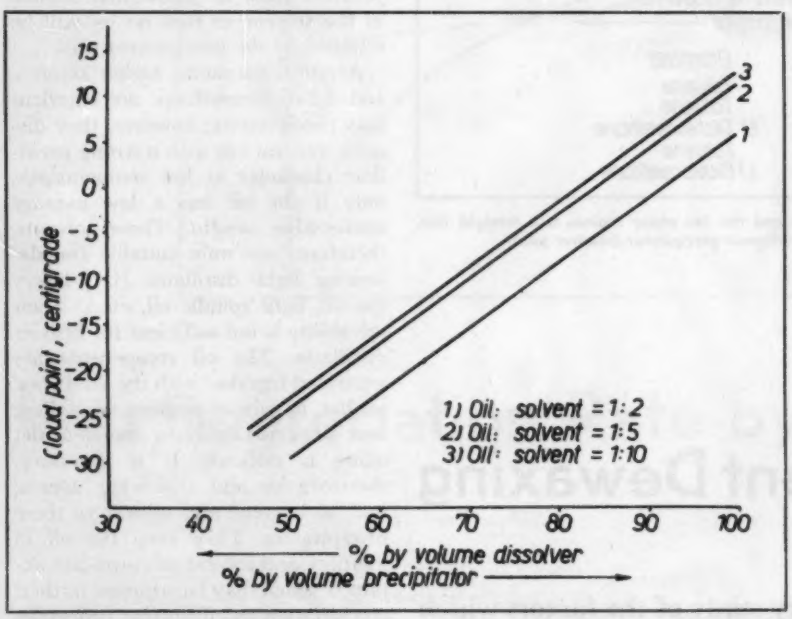


FIGURE 3—Changing the oil-solvent ratio does not change the slope of the phase boundary line.

influencing of solubility; general rules are difficult to establish. The reproducibility of the analytic methods carried out up to now is especially problematic. The results of the following research work should serve to clarify these difficulties.

Formation. The formation of a second liquid phase which adheres to the wax (slabby participation) is an unwelcome side effect which sometimes occurs while precipitating waxes from oil-solvent mixtures. To show this, a common dewaxed oil was cooled with different solvent mixtures and the formation of the second liquid phase was observed. The properties of the oil are reported in Table 1. The results of the phase separations are shown in Figure 1 (actual values are shown in Appendix Table i).

It may be seen from Figure 1 that the boundary lines between the one-phase region and the two-phase region are straight lines. The general equation for a straight line is:

$$y = kx + b$$

whereby k—as later tests will show—is independent of the oil and merely a criterion for the solvent mixture just used. The term b depends as well on the oil as on the solvent mixture, and represents the degree of selectivity of the precipitator and dissolver couple. Values for k are given in Table 2. The ratio of precipitator required to achieve phase separation

TABLE 1
A Common Dewaxed Oil

Specific Gravity, 15C/15C	0.8960
Pour Point, C	—30
Viscosity @ 50C, cs	157.22
Viscosity @ 100C, cs	21.52
Viscosity Index	94.5

TABLE 2
Slope of Phase Boundary Lines

Precipitator	Dissolver	k
Acetone	Toluene	2.15
Butanone	Toluene	1.35
1.2-Dichloroethane	Toluene	1.23
Butanone	1.1-Dichloroethane	1.05
1.2-Dichloroethane	1.1-Dichloroethane	0.72

TABLE 3
Precipitator Required for Phase Separation

PRECIPITATOR-DISSOLVER PAIR	PERCENT PRECIPITATOR	
	0 C	10 C
Acetone-Toluene	46.0	41.5
Butanone-1.1-Dichloroethane	64.5	54.5
Butanone-Toluene	72.0	64.5
1.2-Dichloroethane-1.1-Dichloroethane	91.0	70.0
1.2-Dichloroethane-Toluene	90.5	82.5

TABLE 4
Austrian Paraffinic Raffinate

Specific Gravity, 15C/15C	0.8938
Pour Point, C	16
Viscosity @ 50C, cs	75.40
Viscosity @ 100C, cs	12.30
Viscosity Index	84.5
Cloud Point (in 1,2-dichloroethane), C	—1.0

TABLE 5
Comparison of Regions for Dewaxing

	One Phase	Two Phase
Solvent Mixture		
1,1-Dichloroethane, percent	24	10
1,2-Dichloroethane, percent	76	90
Dewaxed Oil		
Specific Gravity, 15C/15C	0.8951	0.8956
Pour Point, C	—15.5	—18.5
Viscosity @ 50C, cs	79.39	78.75
Viscosity @100C, cs	12.45	12.34
Viscosity Index	76.5	75.0
Wax		
Weight Percent of Chg	4.5	6.0
Melting Point, C	57	48
Oil Content, Weight Percent	3	27
Dewaxed Oil in Solvent		
Cloud Point, C	—18	—8

Here's How to Do Laboratory Dewaxing . . .

The right solvent composition for dewaxing a certain oil is determined in the following manner:

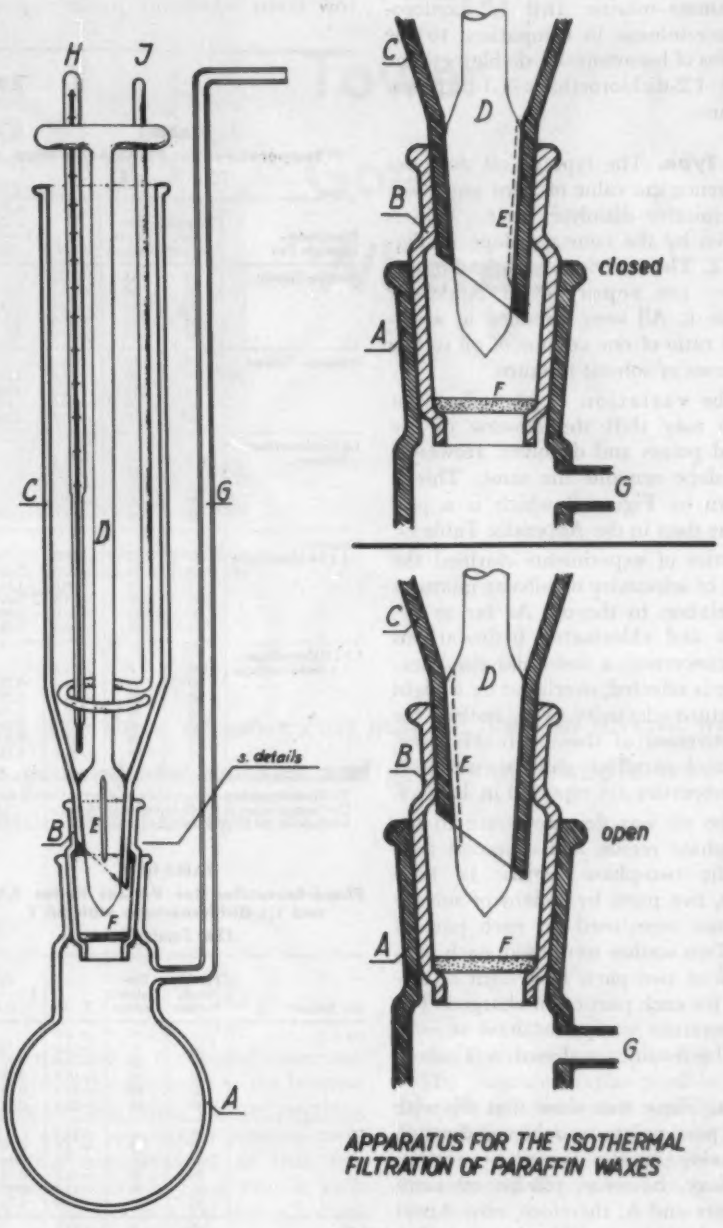
First approx. 30 grams of oil are dewaxed at —25 to —30 C with five times the quantity of a mixture of 30 percent 1,2-dichloroethane and 70 percent 1,1-dichloroethane. This way all hard waxes and the largest part of soft waxes are removed from the oil. After distilling the solvent and removing the last remainders in vacuum by means of stripping gas, the cloud point of the oil is determined in pure 1,2-dichloroethane and in a mixture of 80 percent Vol. 1,2-dichloroethane and 20 percent Vol. 1,1-dichloroethane. Thereby the position of the phase boundary line is obtained. The composition of the precipitator-dissolver mixture which permits dewaxing in the one-phase region, can now be determined graphically for every requested dewaxing temperature.

At this point we must explain why the removal of paraffins needs to be done with a mixture of 30 percent Vol. 1,2-dichloroethane and 70 percent Vol. 1,1-dichloroethane for determining the position of the phase boundary line. The highest cloud point of an oil which we found was +13.5 C so that the maximum cloud point for common oils may be presumed at +15.0 C. Furthermore, the slope ($K = \tan. \alpha$) of the phase boundary line for the mixture of 1,2-dichloroethane amounts to 0.75. Therefore, the stated mixture is in any case satisfactory in view of the claimed demands that no oil components are separated with the paraffin at the given temperatures of —25 to —30 C.

For various tests, as well as for carrying out dewaxing in laboratory, the following apparatus for isotherm filtration proved to be satisfactory during our various research activities:

It consists of a glass tube C in which the solution to be filtered is filled. This tube is equipped with a stirrer J and a thermometer H and is closed through a ground joint with a handle. The ground joint has a furrow E, which corresponds with a furrow in the inside ground joint E' of the glass tube. If placed in the right position, the solution in the tube can flow down into the filter crucible which is grinded onto the tube. The filter crucible has another ground joint on the outside onto which a ground joint fits which is on the neck of the flask A serving for reception of the filtrate. The flask is equipped at the side with a small glass tube G which leads upwards and is connected to a suction pump. The whole apparatus is laid out in a way that it can be installed in a 3-litre Dewar container with a cooling medium for the temperatures to be obtained.

The isotherm filtration is carried out in a way that the solution to be filtered is filled into the glass tube C and is cooled under stirring to the requested temperature. Then the canal J is opened by turning the ground joint with the handle while at the same time the vacuum pump sucks at the tube C. The solution flows into the receiver flask while the precipitated wax is filtered.



APPARATUS FOR THE ISOTHERMAL FILTRATION OF PARAFFIN WAXES

is shown in Table 3—these values are synonymous with the b terms.

These experimental results lead to the following conclusions: acetone has the highest selectivity for the oil, then follows butanone, while 1,2-dichloroethane is the least selective precipitator. Toluene shows better dissolving properties than 1,1-dichloroethane, as may be seen from the higher slope of the curves of butanone-toluene and 1,2-dichloroethane-toluene in comparison to the curves of butanone-1,1-dichloroethane and 1,2-dichloroethane-1,1-dichloroethane.

Oil Type. The type of oil does not influence the value of k for any given precipitator-dissolver pair. This is shown by the constant slope in Figure 2. The individual results for this figure are reported in Appendix Table ii. All were obtained at a solvent ratio of one volume of oil to five volumes of solvent mixture.

The variation of the oil-solvent ratio may shift the relation of the cloud points and dissolver. However, the slope remains the same. This is shown by Figure 3 which is a plot of the data in the Appendix Table iii.

Series of experiments clarified the type of selectivity of solvent mixtures in relation to the oil. As far as ketones and chlorinated hydrocarbons are concerned, a molecular-size-selectivity is effected, overlayed by a slight structure-selectivity. For testing the effectiveness of these selectivities, Austrian paraffinic raffinate was used. Its properties are reported in Table 4.

The oil was dewaxed once in the one-phase region and a second time in the two-phase region. In both cases, five parts by weight of solvent mixture were used for each part of oil. Two washes were used, each consisted of two parts by weight of solvent for each part of oil charged. The temperature was maintained at —15 C. The results are shown in Table 5.

Tests. These tests show that oils with good pour points are achieved through dewaxing in the two-phase region; the wax, however, retains oil components and is, therefore, oily. Apart from that, it may be observed that the dewaxed oil has a lower viscosity index than the oil dewaxed with the right solvent composition.

Results described in this paper show as substantial factors for dewaxing, kind, quantity and composition of the precipitator-dissolver pair, but likewise the properties of the oil to be dewaxed. For achieving high-quality oils and waxes, it is necessary to dewax in the region of only one liquid phase. This will demand—according to our investigations—the use of a solvent composition lying within narrow limits which are predetermined for the chosen conditions on the basis of the linear boundary line between the one and the two-phase region.

These tests showed, furthermore, that the mixture of 1,2- and 1,1-dichloroethane in respect to the position of the phase boundary line, is more favorable than all dewaxing mixtures in use. The low slope of the boundary line permits an easy dosage of the dissolver for achieving the best dewaxing results.

Part 2 will appear in an early issue of the PETROLEUM REFINER.

APPENDIX

TABLE I
Temperature for Phase-Separation
(See Figure 1)

Precipitator-Dissolver Pair	Precipitator, Percent	Dissolver, Percent	T, °C	$k=\frac{\Delta T}{\Delta C}$
Acetone-Toluene	55	45	+19.0	....
	50	50	+ 8.0	2.2
	45	55	— 2.0	2.0
	40	60	—13.0	2.2
	35	65	—24.0	2.2
Butanone-Toluene	90	10	+24.5	....
	80	20	+11.0	1.35
	70	30	— 2.0	1.30
	60	40	—16.0	1.40
	50	50	—29.5	1.35
1.2-Dichloroethane-Toluene	100	0	+11.5	....
	90	10	— 0.5	1.2
	80	20	—12.5	1.2
	70	30	—24.5	1.2
	65	35	—31.0	1.3
Butanone-1.1-Dichloroethane	90	10	+27.0	....
	80	20	+16.5	1.05
	70	30	+ 6.0	1.05
	60	40	— 4.5	1.05
	50	50	—15.0	1.05
	40	60	—25.5	1.05
1.2-Dichloroethane-1.1-Dichloroethane	100	0	+11.5	....
	90	10	+ 4.5	0.70
	80	20	— 3.0	0.75
	70	30	—10.0	0.70
	60	40	—17.0	0.70
	50	50	—24.0	0.70
	40	60	—31.5	0.75

T=Phase-separating Temperature in degrees Centigrade.
C=Concentration of the Precipitator in % Vol.
k=Slope of the Phase Boundary Line.

TABLE iii
Phase-Separation for Various Ratios 1,2- and 1,1-Dichloroethane with Oil 1
(See Figure 3)

Oil: Solvent	Precipitator, Percent	Dissolver, Percent	T, °C	$k=\frac{\Delta T}{\Delta C}$
1:2	100	0	+ 6.0	....
	90	10	— 1.0	0.70
	80	20	— 8.0	0.70
	70	30	—15.5	0.75
	60	40	—22.5	0.70
	50	50	—29.5	0.70
1:5	100	0	+11.5	....
	90	10	+ 4.5	0.70
	80	20	— 3.0	0.75
	70	30	—10.0	0.70
	60	40	—17.0	0.70
	50	50	—24.0	0.70
1:10	100	0	+12.5	....
	90	10	+ 5.5	0.70
	80	20	— 1.5	0.70
	70	30	— 9.0	0.75
	60	40	—16.0	0.70
	50	50	—23.0	0.70

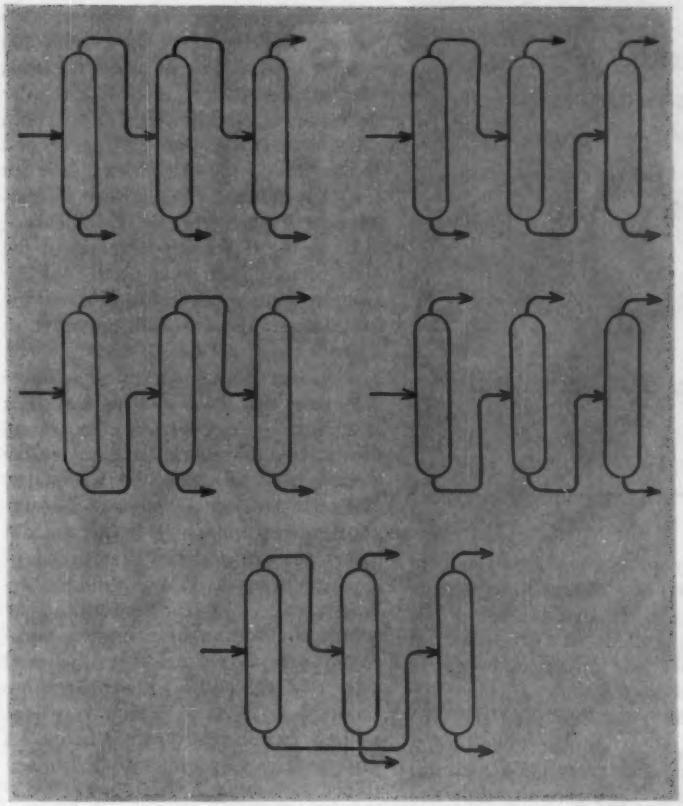
TABLE ii
Phase-Separation for Different Oils with 1,2-1,1-Dichloroethane
(See Figure 2)

	Precipitator, Percent	Dissolver, Percent	T, °C	$k=\frac{\Delta T}{\Delta C}$
Oil 1	100	0	+11.5	....
	90	10	+ 4.5	0.70
	80	20	— 3.0	0.75
	70	30	—10.0	0.70
	60	40	—17.0	0.70
	50	50	—24.0	0.70
	40	60	—31.5	0.75
Oil 2	100	0	+11.0	....
	90	10	+ 4.0	0.70
	80	20	— 3.5	0.75
	70	30	—10.5	0.70
	60	40	—17.5	0.75
	50	50	—25.0	0.75
	40	60	—32.0	0.70
Oil 3	100	0	+13.5	....
	90	10	+ 6.5	0.70
	80	20	— 0.5	0.70
	70	30	— 7.5	0.70
	60	40	—15.0	0.75
	50	50	—22.0	0.70
	40	60	—29.5	0.75
Oil 4	100	0	— 1.5	....
	90	10	— 9.0	0.70
	80	20	—16.0	0.75
	70	30	—23.0	0.70
	60	40	—30.0	0.70
Oil 5	100	0	— 9.5	....
	90	10	—16.5	0.70
	80	20	—24.0	0.75
	70	30	—31.0	0.70
Oil 6	100	0	— 5.0	....
	90	10	—12.0	0.70
	80	20	—19.5	0.75
	70	30	—26.0	0.65
	65	35	—30.0	0.70

Oil Identification:

No.	DESCRIPTION	Spec. Grav. 15C/15C	V_{50} cs	V_{100} cs	V. I.
1	Austrian Solvent Raffinate (Zisterdorf)	0.8960	157.22	21.52	94.5
2	Pennsylvanian Solvent Raffinate	0.8790	71.46	13.52	113.0
3	Pennsylvanian Bright-Stock	0.8942	258.5	31.25	95.0
4	Austrian Solvent Raffinate (Matzen)	0.9031	90.80	13.50	61.0
5	Austrian Commercial Raffinate (Matzen)	0.9275	134.62	16.11	53.0
6	Colombian Raffinate	0.8942	72.76	11.45	74.0

With many combinations possible for distillation steps . . .



Which Tower Goes Where?

FIGURE 1—Five arrangements are possible for making four products with three towers. This article gives some rules for deciding which arrangement will give the best separation for any number of products.

Separation of a feed into three or more cuts may be done in several ways. This author explains the main principle to consider and gives some simple rules-of-thumb for choosing the best distillation arrangement.

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IN THE DESIGN of distillation systems a frequent requirement is that of separating a single feed stream into three or more fractions. In these cases two or more towers are required and a decision must be made as to the feed arrangements for the succeeding towers.

As the simplest example, if a feed stream is to be divided into three parts then two towers are required. But the feed to the second tower can be either the overhead or the bottoms from the first tower. We are assuming that sharp separations between components are desired so that side streams cannot be used, that is, each tower gives only a top and a bottom product. If a single stream is to be separated into four cuts then three towers are required and there are five possible arrangements of the feeds. These are diagrammed in Figure 1.

The number of the possible feed arrangements increases rapidly with increasing numbers of towers. Thus there are 14 possible arrangements of 4 towers and 42 possible arrangements of 5 towers.

The problem, then, is to organize a line of reasoning that leads as simply and directly as possible to the particular one of the possible tower

Which Tower Goes Where? . . .

The most economical distillation system is one which requires the least amount of heat to carry out the separations. When choosing the best arrangement, there is usually an advantage achieved from the following conditions:

- **Minimum quantities for difficult separations.**
- **Separations made near a 50-50 split.**

arrangements that is the optimum. Because this is the sort of thing that can easily become over-complicated, the need will be to carefully exclude all of the extraneous variables that might seem to have significance but which actually are quite unimportant.

Basis of Selection. First step is to obtain a basis of comparison for the various tower arrangements. Obviously this basis must be economic, the comparable dollar costs of providing the required separations between the components. The dollar costs of operating a distillation system are of two kinds, fixed costs that are independent of the tower arrangement, and variable costs which are not. Of these variable costs there is one that is of overwhelming importance, the cost of the heat that it is necessary to degrade across the columns to give the separations. The cost of no other variable is more than a very small fraction of this. Indeed it can almost be said that no other variable exists.

A distillation system is nothing quite so much as a heat transfer mechanism. The principal cost of operating this mechanism, of course, is for the heat supplied to the reboiler. But to this source cost must be added the costs of transferring the heat and of removing it in the condenser. Thus the cooling water cost depends on the quantity of heat. Also the equipment involved, the surfaces of the reboiler and condenser, the area of the plates, even the size of the reflux pumps, are all directly proportional to the heat use. Then not only the operating costs, but also the first or capital cost of the equipment and the cost of maintenance are direct functions of the quantities of heat.

It can be concluded then that the total heat inputs to the towers of a system provides a very good measure of the tower arrangement, that the optimum such arrangement requires the minimum of heat. But the actual heat input to a tower is proportional to the theoretical minimum heat duties (infinite plates) required to give the complete separation between the cut components, the so called "minimum reflux." This condition of minimum heat need, then, can be related directly to the components present in the feed mixture, and is the final basis for the selection of the tower arrangements.

There are two particular points that need to be emphasized here. An easy and common idea on this subject—of the type that "everyone knows"—is that there is some sort of automatic compensation operating in the heat needs of these tower arrangements, that it is useless to try to save heat in one tower as it will only be added in another tower, that the total heat duty for all of the towers is necessarily a constant independent of the arrangement. The first point, then, is that this is not so, that there is no automatic compensation here, that the total heat requirements can and do vary widely with the tower arrangements used, that the heat savings that can result from the deliberate selection of the optimum tower arrangements are very real.

A second easy idea is that this matter of the feeds to the succeeding towers is taken care of in our common design methods, that if the regular procedures are followed, the optimum arrangement will result. The second point, then, is that this idea also is not so, that normal design does not include either the totaling of the heat uses or the deliberate selection of the case of minimum heat need, that the heat requirements resulting from the usual methods are quite a matter of chance.

Consider actual operations. There are many two tower systems for which a change in the feed to the second tower would result in a considerable saving in heat. And the writer has not seen data for a system of three or more towers for which it was not obvious that substantial quantities of heat could be saved by a different arrangement. This is necessarily one man's observation of a limited number of cases. Nevertheless it is believed that this subject of tower arrangements is an area in which very real savings can be made rather easily, an area well worth deliberate consideration.

Two Principles. This matter of selecting a tower arrangement on the basis of minimum heat need resembles a pie that can be cut into slices from any angle. Some means of drawing lines on this pie dividing between "more heat" and "less heat" needs to be arranged. Two right angle cuts of this pie are provided by the two principles described below. The writer has found that these rules seem "natural" for comparing the tower arrangements and for the quick elimination of most of the possibilities. Frequently these rules cause the single optimum arrangement to be "obvious."

The first principle can be termed "The advantages of minimum quantities for difficult separations." Certainly it seems reasonable that for heat economy the feed to a tower with high reflux requirements and corresponding large heat needs should be kept to a minimum. Consider how a distillation column works with the following terms:

V — Mols vapor up the column
L — Mols liquid down the column
P — Mols overhead from the column

For the section of column above the

feed $V-L=P$. Also from the vapor-liquid equilibrium relations, the more "difficult" the separation and the closer boiling the cut components the more closely the V/L ratio must approach to 1.0 and the larger V and L must be compared with P. But the heat needs of the column are proportional to the quantities of the counterflowing streams, to the values of V and L. So we have reached the not surprising conclusion that the more difficult separations have the greater heat needs.

But the pertinent point here, we can also say that these heat needs are proportional to the values of P, that decreasing the quantities of the end products by means of the tower arrangements decreases these high heat needs proportionally. Or as we described it, "The advantage of minimum quantities for difficult separations."

Consider quickly the feed arrangement for the two towers necessary to separate the following components:

Products	Mols	Boiling Temp.
A	33	110°
B	34	120°
C	33	140°
	100	

Obviously here *C* should be eliminated before the more difficult separation of *A* and *B* is attempted. Then *C* would be the bottoms from the first tower, and *A* and *B* would be the overhead feed to the second tower. The large quantity of heat required to separate *A* and *B* would be nearly doubled by the presence of *C*.

The second principle can be termed "The advantage of the 50-50 split." It seems reasonable that for economy the heat input to a tower should be used twice, so to speak, it should be needed to provide separations in both the top and the bottom halves of the tower. If the heat is used only once (to provide the separation in one half of the tower) then, by addition, certainly more total heat will be needed. Or in reverse, the greater the utilization the less the heat required.

The fundamental point here is that as far as a distillation system is concerned, the desired division of the feed stream between overhead and bottoms is purely accidental, a matter of chance. Except as we have a choice in the tower arrangements, the overhead bottoms split can vary from 95:5 (or indeed 99:1) to 5:95. But the two halves of the tower separate between the same two cut components, and roughly can be said to require the same ratios of V and L to P for the complete separation. Then the heat needs of the two sections of tower required for the complete separations are proportional to the values of P, the quantities of the end products. Thus it follows that if the quantities of the two end products are made as nearly equal as possible the heat needs of the two halves of the column also become equal and the heat degraded across the tower is used the maximum, once in each half of the column. This leads to the minimum heat need. Or as we stated it, "The advantage of the 50-50 split."

It never works out, of course, that the values of P are exactly the same and the heat needs of the two halves of a column are equal. Always one half or the other will have the greater heat need and be controlling. But we simply do the best we can and approach as closely as possible to the 50-50 split.

Consider the system of two towers for the separation of the following mixture.

Products	Mols	Boiling Temp.
A	25.	100°
B	30.	120°
C	45.	140°
	100.	

Here the arrangement of *A* and *B* as overhead feed to the second tower (*C* is bottoms from the first tower) is obviously the better as it provides a 55-45 split on the first tower and a 25-30 split on the second tower. This compares with a 25-75 split on the

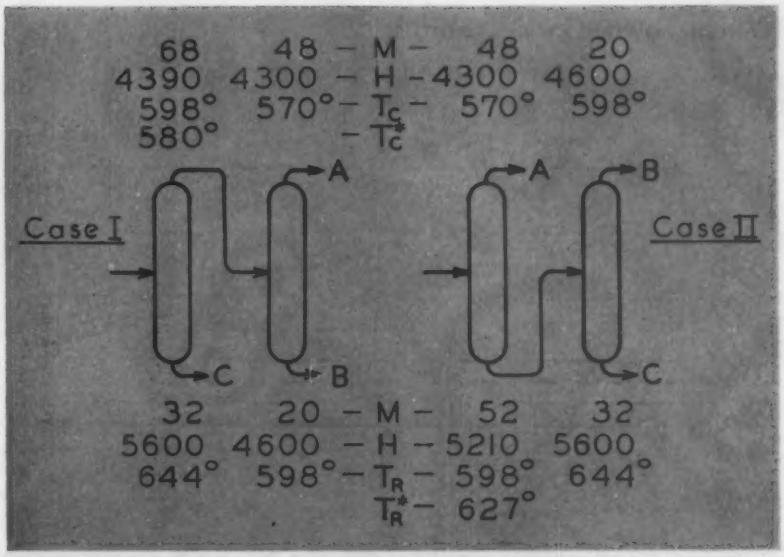

FIGURE 2—Case I represents a savings of about 30% in heat duty over the arrangement of towers shown in Case II.

About the Author

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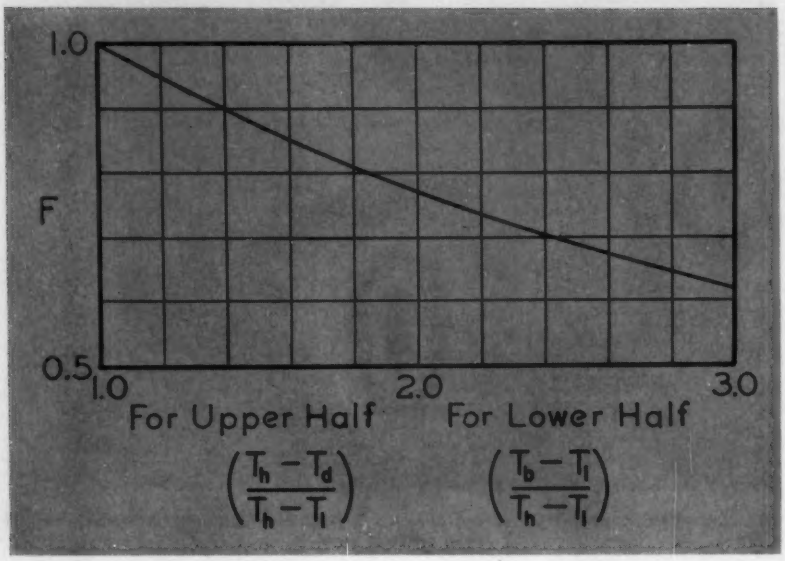


FIGURE 3—A correction is used to take into account the presence of components other than the cut components. To read the "F" corrections, different temperature ratios are used at the top and bottom of the tower.

first tower and 30-45 split on the second tower for the arrangement in which *B* and *C* are a bottoms feed to the second tower (*A* is overhead from the first tower). These separations are equal in difficulty so that the controlling heat needs of the individual towers becomes proportional to their larger values of *P*. The first arrangement gives $55 + 30 = 85$ as the sum of the *P*'s for the more heavily loaded sections of the towers, as compared with a value of $75 + 45 = 120$ for the second arrangement. The first arrangement, then, represents a savings of about 30 percent in heat duty over the second arrangement. Obviously for the second arrangement a large part of the heat inputs required for the bottom halves of the two towers is wasted in the upper halves. This example should be sketched out in the manner of Figure 2 by anyone to whom these values are not clear.

Heat Relation. The two principles just described are quite rough and are intended only to eliminate most of the possible tower arrangements. They cannot, of course, differentiate between arrangements that are reasonably close in their heat needs. Some quick method of approximating the heat requirements of the various towers of a system is needed so that the arrangement with minimum heat need can be selected. For this the use of the following summation is suggested:

$$\Sigma\ (MH)\ F\left(\frac{T_h}{T_h - T_l}\right) = \text{Minimum}$$

where

(MH) — Mols of product times heat of vaporization. Heat required to vaporize total overhead product in the condenser or total bottoms product in the reboiler. Btu per 100 mols feed to tower system.

F — Factor from Figure 3. Correction for presence of components other than cut components. Different for two halves of column.

T_l — Boiling point of light cut component at tower pressure. Degrees absolute.

T_d — In Figure 3, dew point of overhead product at tower pressure. Degrees absolute.

T_h — Boiling point of heavy cut component at tower pressure. Degrees absolute.

T_b — In Figure 3, bubble point of bottoms product at tower pressure. Degrees absolute.

The value of the expression (MH) $F\left(\frac{T_h}{T_h - T_l}\right)$ for a half of a column is proportional to the theoretical minimum heat need for providing a complete separation (with infinite plates) between the cut components. For each tower the value of the expression is determined for the half of the tower that has the greater heat need and is controlling—that is, the half that has the greater value of the expression. These values are summed for the towers of a particular arrangement. The arrangement with the lowest value of the sum of these expressions has the minimum total heat need and is the optimum arrangement. The use of this summation is illustrated in the simple examples that follow.

The (MH) and *F* terms, of course, are different for the two halves of the column. F = 1.0 when the product from the half column is a single component. The term $\left(\frac{T_h}{T_h - T_l}\right)$ measures the difficulty of separating the cut components and is the same for both halves.

Procedure and Examples. Two principles are used to eliminate part or most of the possible tower arrangements, and those remaining are compared by means of the heat summation. As stated before, the optimum is the one that requires minimum heat. It can happen, of course, that near identical results are obtained for two different arrangements so that a more detailed design is necessary to make a selection between them. Complete detailed economic studies of any of these alternates can be made, of course, and the purpose of the short cut methods is only to save time—to reach the optimum arrangement as quickly as possible.

Two brief examples of simple two-tower systems will be given to illustrate the methods described. For the first example, consider the following mixture to be separated into the three components.

Component	M (Mols)	Boiling Temperature (F)	H (Btu/Mol)
A	32	105	3850
B	24	119	3970
C	44	145	4400
	100		

The question, of course, is whether the feed to the second tower should be the overhead or the bottoms from the first tower.

From the boiling temperatures it is

seen that *B* is more difficult to separate from *A* than it is from *C*. By our first principle "The advantage of minimum quantities for difficult separations," *C* should be eliminated before *A* and *B* are separated. Then the first tower should have *C* as the bottoms and *A* and *B* as an overhead feed to the second tower.

For the second principle, from the number of mols it is seen that if *A* only is taken overhead from the first tower the split is 32-68 for the first tower and 24-44 for the second tower. But if *A* and *B* are both taken overhead the split is 56-44 for the first tower and 32-24 for the second tower. Then from the rule "The advantage of the 50-50 split," it is seen that here also *A* and *B* as overhead should be the feed to the second tower.

The two principles are in agreement and the overhead from the first tower should be the feed to the second tower. The working through of the heat summation would give the same result but would take at least some time. With the use of the two principles the conclusion is immediately obvious. As stated before, the value of these rules is in the rapid elimination of most of the possible tower arrangements.

For the second example, consider the following mixture also to be separated into the three components.

Component	M (Mols)	Boiling Temperature (F)	H (Btu/Mol)
A	48.	110	4300
B	20.	138	4600
C	32.	184	5600
	100.		

As before, the question is whether the feed to the second tower should be the overhead or the bottoms from the first tower.

From the first principle it would seem that *C* should be eliminated before the more difficult separation of *A* and *B* is performed. But from the second principle, a 48-52 split on the first tower (*B* and *C* in the bottoms) is better than a 68-32 split (*C* only in the bottoms). Then the two principles are opposed to each other and the use of the heat summation is required to select the optimum.

The data for the two possible arrangements were summarized earlier in Figure 2. For Case I it is seen that for each tower the top half is controlling in heat need, that is, for each tower the numerical value of the expression of the summation is larger for the top half than for the bottom half. For the top half of the first tower the dew point of the overhead as vapor is calculated to be 120° ($T_d = 580$) so that from Figure 3, $\left(\frac{T_b - T_d}{T_b - T_l}\right) = 1.39$ and F = 0.90. Then the heat summation for Case I is:

1st Tower
$68 \times 4390 \times 0.90 \times 644/(644 - 598) = 3{,}760{,}000$

2nd Tower
$48 \times 4300 \times 1.0 \times 598/(598 - 570) = 4{,}410{,}000$

8,170,000

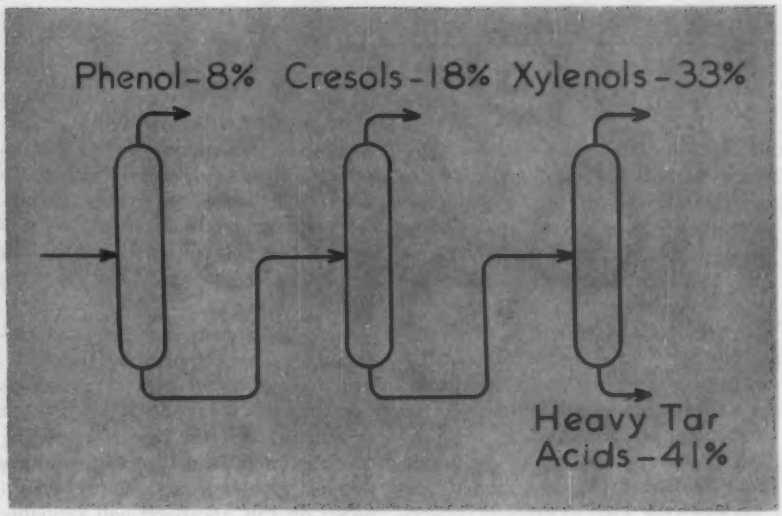


FIGURE 4—Usually a linear system of towers is used. In this case, the worst possible arrangement results.

For Case II it is seen that for both towers the bottom half is controlling in heat need. For the bottom half of the first tower the bubble point of the bottoms product is calculated to be 167° ($T_b = 627$) so that from Figure 3, $\left(\frac{T_b - T_l}{T_h - T_l}\right) = 2.04$ and F = 0.77. Then the heat summation for Case II is:

1st Tower
$52 \times 5210 \times 0.77 \times 598/(598 - 570) = 4{,}460{,}000$

2nd Tower
$32 \times 5600 \times 1.0 \times 644/(644 - 598) = 2{,}510{,}000$

6,970,000

The heat needs for the two arrangements, of course, are proportional to the sums 8,170,000 and 6,970,000. From these values we can say that Case II is the optimum arrangement by a considerable margin. This example shows how easy the saving of 17 percent of the total heat needs of a distillation system can be.

In this example the strong effect of "The advantage of the 50-50 split" will be noted. The principal differences in the summations obtained resulted from being able to use values of M of 52 and 32 for Case II as compared with 68 and 48 for Case I.

Obviously a number of shortcuts and simplifications were used in this calculation. It is common practice to design for specified amounts of impurities in the product streams. But in the use of the entropy type relations, the natural and easiest basis is the complete separation between the components, that is, no heavy cut component in the overhead and no light cut component in the bottoms. Actually the effect on the theoretical minimum heat needs of including these impurities is quite small. Then the calculations of the T_h and T_l values for each tower can be based on the complete separation, as was done in the above example. This shortens the calculations by reducing the number of components, and also eliminates the troublesome bother of guessing amounts of the impurities.

It will also be noted that the atmospheric boiling temperatures were used in determining the values of T_h and

T_1. The term $\left(\frac{T_h}{T_h - T_l}\right)$ changes slowly with pressure, and for low pressure towers such as these no correction for pressure need be made. For higher pressure towers—over 100 pounds—a tower pressure must be assumed and the corresponding condenser and reboiler temperatures used. This matter of the tower arrangement is, of course, the first step of the design of a distillation system, and it is desirable to keep the number of assumptions subject to later change to a minimum.

Feed Preheat. The background has been given for a subject closely related to that of the tower arrangements and one the writer has not seen analyzed in the distillation literature. This subject is the preheat in the feed to a column: the amount that is desirable, the dollar value that can be assigned to it, and the means of supplying it. It is usually thought that the feed should be "hot" and one rule that the writer has heard is that the percent of the feed vaporized should equal the percent of the overhead product.

It has been shown that there is no relation between the heat needs of the two halves of a column, that they are quite independent of each other and are a matter of chance. Almost always one half of the column will be controlling and will require substantially more heat than the other half. For a first case, consider a column for which the larger heat need is in the half above the feed. Obviously for this, heat from the feed is equally as useful as heat from the reboiler. Then feed preheat can be assigned practically the full dollar value of reboiler heat. As a result considerable sums of money can be justified for exchangers to supply as much preheat as possible.

The second and opposite case is the one in which the controlling heat need is in the half below the feed. Here heat added to the feed serves no useful purpose and so must be assigned a value of near zero. Inded "coolness" in the feed can be considered almost equal in value to condenser cooling. While a warm feed stream would not be cooled, certainly any dollar cost for heating the stream cannot be justified.

There are, of course, many columns for which the heat needs of the top and bottom halves are so nearly equal that either can be made controlling by the amount of the feed preheat. In these three cases—because the heat itself usually costs more than the heat removal or cooling—the feed preheat should be sufficient so that the heat need of the lower half becomes controlling.

This conclusion that for most columns the feed temperature should be an extreme, either cold or as hot as possible, may seem odd at first. But it is believed that the line of reasoning given is valid, and that the resulting designs give satisfaction. A design based on this approach will probably be closer to the optimum than one based on a vague feeling that feed preheat is "good."

Consider briefly the feed preheats that would seem economic for the two systems of Figure 2. For Case I the upper halves of both columns are controlling in heat need so that maximum amounts of preheat for both feeds are indicated. One arrangement would be to exchange the feed to the first column with both of the bottom product streams, and to take a vapor overhead from the first tower as feed to the second tower. There is a tendency to have a prejudice against such an all-vapor feed as a control problem, but actually it is a quite satisfactory arrangement.

In Case II the bottom halves of both towers are controlling in heat need so that feed preheat should be kept to a minimum. No heat would be put into the feed to the first tower except as required to hold temperature and the hot feed to the second tower would not be heated further.

The feed preheat arrangements for any system of multiple towers can be worked out along similar lines.

It is noted that the availability and usableness of feed preheat can affect the selection of a tower arrangement. Because feed preheat by exchange is less expensive than reboiler heat, tower arrangements are favored which can use this heat, that is, arrangements in which the top halves of the columns are controlling in heat need. Such effects can easily be included in the heat summations for the towers if desired. Usable feed preheat (top half of the column controlling) is simply subtracted from the total heat need of the column to give the net reboiler requirement. The details of doing this will be obvious to anyone working with a particular system.

Differences from Usual Systems. We can discuss briefly how tower arrangements that follow the discussion given here will differ from our usual systems. In general we follow quite well the rule of "The advantage of minimum quantities for difficult separations." Thus propane is separated out before splitting the iso and normal butanes.

But the rule of "The advantage of the 50-50 split" is not followed. We just do not think in terms of half columns. And the combining of a half column with a high heat need and a half column with a low heat need causes no concern. The most common arrangement is a linear one, a row of towers the feed to each of which is the bottoms from the previous tower. The products from the lightest to the heaviest are the overheads from the succeeding towers.

Because the towers can be of decreasing pressure, this arrangement can have the advantage that no pumps are required to put the bottoms from one tower into the feed zone of the next. Unfortunately the columns are frequently arranged in this manner because it is common, and then the pumps are put in just to be "safe." Also this arrangement is supposed to have the advantage of giving each tower a "hot" feed. This does not apply. (See the discussion of feed preheat.)

Actually for most cases this linear arrangement practically guarantees high heat requirements for the towers. The bottom halves are very much controlling in heat need, and the top halves have little use for most of the heat put through them. The cost of the pumps that may be saved are quite insignificant compared with the cost of these high heat inputs.

An example of such a linear system from the coal tar industry—unique in that it is exactly the worst possible tower arrangement from the heat standpoint—is shown in Figure 4. "Sprung" tar acids are separated into phenol, cresols, xylenols and heavier in towers operated under vacuum. Sharper separations could be obtained with much less heat by using an arrangement derived from the simplifying principles described. # #

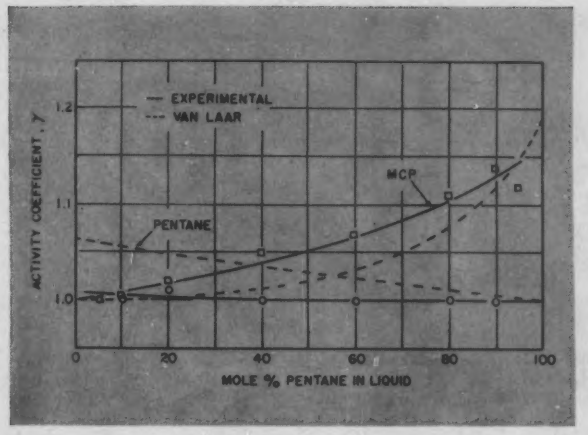


FIGURE 1—Activity coefficients for the pentane-methylcyclopentane system at 760 mm Hg.

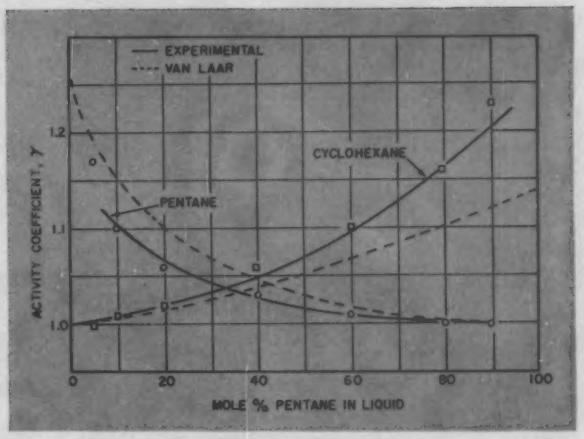


FIGURE 2—Activity coefficients for the pentane-cyclohexane system at 760 mm Hg.

V–L Equilibrium for Naphthenes and Paraffins

See also the summary on the studies of aromatics.

H. S. Myers, C F Braun and Company, Alhambra, Calf.

THREE EARLIER articles[4, 8, 9] give experimental vapor-liquid equilibrium data for binary mixtures of paraffins and aromatics, and for naphthenes and aromatics. This article presents similar data for mixtures of naphthenes and paraffins.

Volatility characteristics of naphthene-paraffin mixtures are generally believed to be ideal, but very little actual data have been published to substantiate this belief. Only a few systems have been reported in detail in the literature. Bromiley and Quiggle[1] in 1933, and Sieg[14] in 1950, published equilibrium data for heptane-methylcyclohexane. In this same paper, Sieg also reports data for cyclohexane-heptane. Harrison and Berg[3] have studied the system cyclohexane—2,2,3-trimethylbutane and methylcyclohexane—2,2,4-trimethylpentane.

This article gives experimental vapor-liquid equilibrium data for seven binary mixtures at 760 mm Hg absolute pressure.

Pentane-methylcyclopentane
Pentane-cyclohexane
Pentane-methylcyclohexane
Hexane-cyclohexane
Hexane-methylcyclopentane
Hexane-methylcyclohexane
Cyclohexane-heptane — also reported by Sieg[14]

In addition, isothermal data at 40 C are given for the system pentane-cyclohexane.

Apparatus—The equilibrium-still used for this study has been described previously.[4] It is of the vapor-recirculating type. All parts are glass except for the Teflon sample-valves. Nitrogen ballast is used to maintain an absolute pressure of 760 mm Hg in the system.

Hydrocarbons—All of the hydrocarbons discussed in this work were purified before use. Complete details concerning the source, the method of purification, and the physical properties of each of the hydrocarbons is given in one or the other of the two earlier articles of this series.[8, 9]

Analysis—All of the binary mixtures reported here were analyzed by refractive index. The experimental calibration data are listed in Tables 1 through 7. There is an average spread in refractive index of about 500 points on a 4-place refractometer between the pure components of these mixtures, and the refractometer readings can be reproduced to about ∓ 0.2 percent for analyzing these naphthene-paraffin mixtures.

Equilibrium Measurements—Experimental vapor-liquid equilibrium-data for the seven naphthene-paraffin mixtures are shown in Tables 8 through 14. Relative volatilities have been computed from these data and are included in the tables.

Activity coefficients have been computed from the smoothed temperature-composition diagrams, using vapor-pressure data published by the National Bureau of Standards.[10] Figures 1 through 8 show these coefficients.

Check for Thermodynamic Consistency—Data for the first four sys-

TABLE 1
Refractive Index Calibrations for Mixtures of Pentane and Methylcyclopentane

Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}	Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}
0.0	1.4097	61.25	1.3779
11.59	1.4038	71.56	1.3725
26.97	1.3958	75.80	1.3702
38.68	1.3897	79.48	1.3683
46.14	1.3858	100.00	1.3575
52.81	1.3823		

TABLE 2
Refractive Index Calibrations for Mixtures of Pentane and Cyclohexane

Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}	Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}
0.0	1.4262	58.99	1.3850
9.36	1.4193	67.85	1.3789
18.40	1.4129	76.67	1.3710
27.70	1.4063	89.92	1.3642
39.07	1.3983	100.0	1.3575
48.10	1.3923		

TABLE 3
Refractive Index Calibrations for Mixtures of Pentane and Methylcyclohexane

Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}	Mole Percent Pentane	Refractive Index at 20 C, N_D^{20}
0.0	1.4231	63.61	1.3840
12.30	1.4163	66.67	1.3821
27.08	1.4077	80.77	1.3721
35.75	1.4023	92.77	1.3630
46.52	1.3955	100.00	1.3575
58.62	1.3877		

V–L Equilibrium for Naphthenes and Paraffins . . .

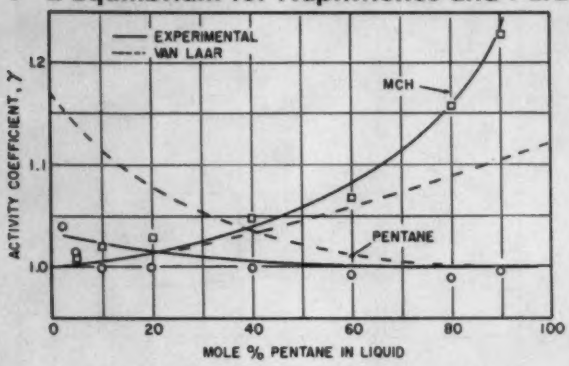
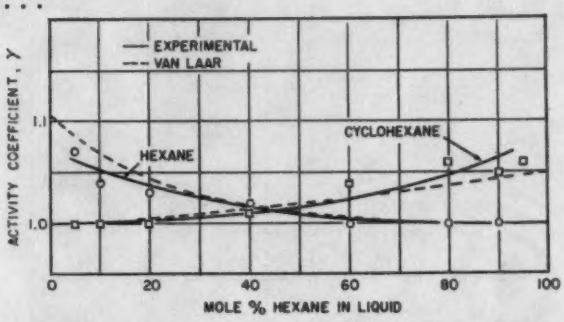


FIGURE 3—Activity coefficients for the pentane-methylcyclohexane system at 760 mm Hg.



FIGUR7 4—Activity coefficients for the hexane-cyclohexane system at 760 mm Hg.

tems were checked for thermodynamic consistency. Since the other three systems were found to be essentially ideal, no check on them was necessary. The Van Laar equations, as given by Gilliland,[12] were used for the check since they contain a temperature-correction term, and the systems to be studied are relatively wide-boiling. The spread between the boiling points of the pure components is 36 C. for pentane-methylcyclopentane, 45 degrees for pentane-cyclohexane, 65 degrees for pentane-methylcyclohexane, and 12 degrees for hexane-cyclohexane.

TABLE 4
Refractive Index Calibrations for Mixtures of Hexane and Cyclohexane

Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}	Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}
0.0	1.4262	52.23	1.3967
7.63	1.4214	55.44	1.3950
18.29	1.4150	76.97	1.3850
30.46	1.4080	89.82	1.3792
35.09	1.4054	100.00	1.3749

TABLE 5
Refractive Index Calibrations for Mixtures of Hexane and Methylcyclopentane

Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}	Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}
0.0	1.4097	51.61	1.3905
7.85	1.4068	60.00	1.3878
16.74	1.4032	70.06	1.3844
19.56	1.4020	88.46	1.3788
24.54	1.4002	89.95	1.3782
34.02	1.3968	100.00	1.3749
40.71	1.3940		

TABLE 6
Refractive Index Calibrations for Mixtures of Hexane and Methylcyclohexane

Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}	Mole Percent Hexane	Refractive Index at 20 C, N_D^{20}
0.0	1.4231	50.00	1.3991
6.72	1.4199	63.04	1.3930
9.39	1.4187	73.44	1.3879
10.37	1.4181	81.63	1.3840
16.64	1.4151	90.51	1.3797
40.23	1.4039	91.34	1.3792
47.51	1.4003	100.00	1.3750

TABLE 7
Refractive Index Calibrations for Mixtures of Cyclohexane and Heptane

Mole Percent Cyclohexane	Refractive Index at 20 C, N_D^{20}	Mole Percent Cyclohexane	Refractive Index at 20 C. N_D^{20}
0.0	1.3877	69.66	1.4106
15.53	1.3919	80.71	1.4156
30.43	1.3963	90.30	1.4205
44.82	1.4010	100.00	1.4262
55.32	1.4049		

TABLE 8
Vapor-Liquid Equilibrium Data for the System Pentane-Methylcyclopentane Pressure = 760 MM HG

Mole Percent Pentane		Temperature, C	Relative Volatility Alpha
Vapor	Liquid		
0.0	0.0	71.80	.....
5.8	1.9	70.40	3.18
10.85	3.7	69.40	3.17
15.3	5.6	68.25	3.05
17.2	6.8	67.75	2.85
19.2	7.2	67.10	3.06
20.5	8.5	66.95	2.78
25.6	9.9	65.60	3.13
30.15	12.6	64.20	2.99
33.7	14.3	63.40	3.05
41.75	18.8	61.00	3.10
43.3	20.1	60.50	3.04
45.4	21.1	59.80	3.11
47.15	22.6	59.45	3.05
47.85	23.8	59.15	2.94
49.8	24.8	58.50	3.01
53.05	27.05	57.25	3.05
53.6	27.45	57.10	3.05
57.6	30.75	55.80	3.06
59.3	32.05	55.30	3.09
60.6	33.05	54.80	3.12
61.4	34.4	54.35	3.03
64.45	36.7	53.50	3.13
64.8	37.5	53.25	3.07
66.9	40.0	52.35	3.03
68.45	41.75	51.80	3.03
71.15	41.6	50.70	3.06
73.0	47.3	49.80	3.01
75.7	49.8	48.90	3.14
78.1	53.45	47.70	3.11
78.3	53.8	47.60	3.10
78.9	55.1	47.20	3.05
81.8	59.1	46.10	3.11
83.8	62.4	44.75	3.12
85.4	66.2	43.90	2.99
86.9	69.2	43.10	2.95
90.0	75.5	41.70	2.92
90.45	75.8	41.50	3.02
92.55	80.25	40.40	3.06
93.85	84.0	39.55	2.91
95.35	87.4	38.75	2.96
96.15	89.3	38.30	2.99
96.5	89.85	37.9	3.11
98.5	95.75	37.2	2.91
99.6	99.0	36.2	2.47
100.0	100.0	36.05	.....

The dotted curves on Figures 1 through 4, show the Van Laar predictions. Deviations from the experimental curves are considerable, and are worst for the wider-boiling systems. This seems to indicate that the assumption that T log γ is a constant at constant composition, may not be valid for wide-boiling mixtures.

To check this possibility, data on the system pentane-cyclohexane was obtained isothermally at 40 C. Table 15 gives the experimental equilibrium-data from this run. The resulting coefficient curves are plotted in Figure 8.

For this isothermal run, the Van Laar equations predict curves that agree almost exactly with the experimental curves—well within the limits of experimental error.

Conclusions—Some of the naph-

TABLE 9
Vapor-Liquid Equilibrium-Data for the System Pentane - Cyclohexane Pressure = 760 MM HG Absolute

Mole Percent Pentane		Temperature, C	Relative Volatility Alpha
Vapor	Liquid		
0.0	0.0	80.75	.....
3.5	0.8	79.9	4.50
9.3	2.1	78.4	4.78
13.7	3.5	77.2	4.38
21.4	6.2	74.75	4.12
27.15	8.25	73.0	4.15
33.9	10.7	70.8	4.28
39.3	13.5	69.05	4.15
43.25	15.45	67.55	4.17
47.35	17.9	65.95	4.13
51.3	20.0	64.6	4.21
54.0	22.1	63.65	4.23
55.3	22.7	63.0	4.21
58.6	25.4	61.45	4.16
61.55	27.7	60.2	4.18
65.4	31.3	58.5	4.17
68.8	34.5	56.7	4.19
71.35	37.7	55.3	4.12
74.2	40.75	53.95	4.18
77.75	45.3	52.05	4.22
82.1	52.8	49.25	4.10
83.55	55.8	48.3	4.02
86.0	59.5	46.95	4.18
87.5	63.6	45.7	4.01
88.85	66.45	44.7	4.02
91.7	73.0	42.9	4.08
93.5	78.0	41.5	4.06
95.2	83.55	39.95	3.91
96.35	87.6	39.0	3.74
100.0	100.0	36.05	.....

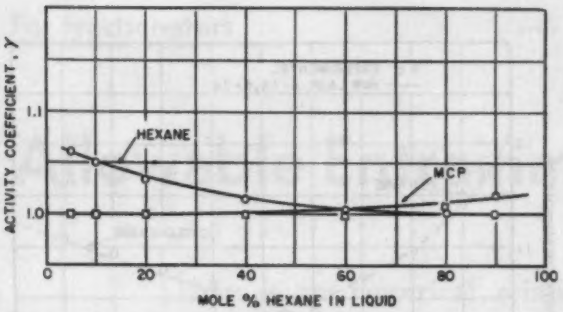


FIGURE 5—Activity coefficients for the hexane-methylcyclopentane system at 760 mm Hg.

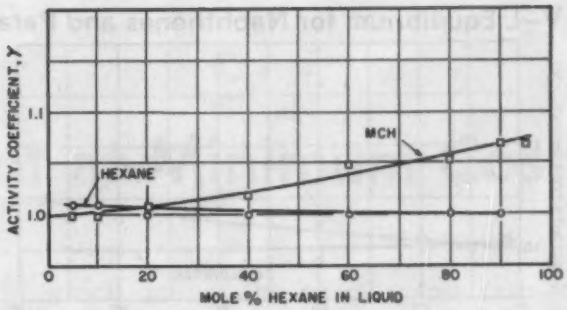


FIGURE 6—Activity coefficients for the hexane-methylcyclohexane system at 760 mm Hg.

thene-paraffin systems studied in this work show measurable deviations from ideality. Deviations are greatest for the wider-boiling mixtures.

The Van Laar equations do not agree closely with the experimental, isobaric data for the wide-boiling systems. But when one of these systems was run isothermally, the Van Laar curves show excellent agreement with the experimental data.

TABLE 10
Vapor-Liquid Equilibrium-Data for the System Pentane-Methylcyclohexane Absolute Pressure = 760 MM HG

Mole Percent Pentane		Temperature, C	Relative Volatility, Alpha
Vapor	Liquid		
0.0	0.0	100.95	.....
7.6	1.15	98.4	7.07
12.6	2.00	97.0	7.06
14.85	2.75	96.15	6.17
23.5	5.05	92.25	5.78
31.8	6.5	89.75	6.72
31.45	6.5	89.75	6.60
33.6	7.5	88.85	6.24
40.8	10.2	86.15	6.07
41.8	9.3	85.55	7.00
42.8	10.7	85.1	6.34
43.5	11.0	84.6	6.23
44.3	10.6	84.65	6.71
44.4	11.0	83.3	6.46
45.5	11.3	84.05	6.55
48.5	12.3	82.6	6.71
55.6	15.2	78.75	6.99
56.2	15.8	78.35	6.84
58.3	16.2	77.15	7.23
62.8	19.5	74.4	6.97
66.9	21.8	72.2	7.25
70.3	24.5	70.0	7.29
77.2	31.3	64.7	7.43
72.5	27.3	68.2	7.02
73.8	28.2	67.35	7.17
75.3	30.2	65.8	7.05
79.6	33.7	63.3	7.68
80.7	36.3	61.2	7.34
83.7	39.4	60.3	7.90
84.2	41.2	59.0	7.61
85.0	42.6	58.0	7.64
85.2	42.3	58.25	7.85
86.7	46.6	56.7	7.47
88.6	49.2	54.5	8.03
89.8	52.3	53.25	8.03
90.3	54.0	52.35	7.93
90.5	55.0	52.0	7.79
91.2	55.8	51.65	8.21
92.0	61.0	49.4	7.35
93.1	63.2	48.2	7.86
94.3	66.9	46.6	8.19
95.1	70.2	45.3	8.24
96.0	74.8	43.95	8.09
96.8	78.8	42.8	8.14
97.7	85.1	41.0	7.44
98.3	88.2	39.7	7.66
99.0	91.7	38.7	8.96
99.2	95.1	37.65	6.39
100.0	100.0	36.05	.....

Summary of Equilibrium Studies for Paraffins, Naphthenes and Aromatics—This article and three earlier articles[4,8,9] give vapor-liquid equilibrium data for mixtures of paraffins, naphthenes, and aromatics. A total of 18 binary systems have been reported.

In general, mixtures of paraffins and aromatics show the greatest deviations from ideality. For the five paraffin-aromatic systems studied, terminal activity coefficients range from about 1.3 to 1.8. For naphthene-aromatic systems, terminal activity coefficients are slightly lower, varying from about 1.2 to 1.4. Narrow-boiling, naphthene-paraffin mixtures are essentially ideal. But for wide-boiling mixtures of naphthenes and paraffins, terminal activity-coefficients can exceed 1.1.

Definite proof of azeotrope formation was found for only one system, methylcyclopentane-benzene. Previous authors[7,11,13] have shown that benzene-cyclohexane also forms an azeotrope, but this system was not studied in the present work.

Marschner and Cropper[7] list an azeotrope for benzene-heptane at 99.3 percent benzene, boiling 0.05 C. Below benzene. Three other investigators of this same system[2,6,14] show no azeotrope.

Marschner and Cropper[7] report an

TABLE 11
Vapor-Liquid Equilibrium-Data for the System Hexane - Cyclohexane Absolute Pressure = 760 MM HG

Mole Percent Hexane		Temperature, C	Relative Volatility, Alpha
Vapor	Liquid		
0.0	0.0	80.8	.....
1.8	0.8	80.6	2.27
3.2	1.9	80.35	1.71
7.0	4.5	80.0	1.61
9.75	6.3	79.75	1.60
13.5	9.35	79.3	1.51
18.7	13.3	78.65	1.50
24.7	18.15	78.0	1.48
31.6	23.85	77.15	1.48
37.3	28.7	76.5	1.48
40.0	31.8	76.05	1.43
45.75	36.9	75.35	1.44
50.5	41.45	74.8	1.44
53.35	44.25	74.5	1.44
55.3	46.2	74.25	1.44
58.35	49.8	73.75	1.41
59.95	51.55	73.6	1.41
61.75	53.55	73.4	1.40
63.0	54.9	73.25	1.40
67.3	59.55	72.75	1.40
72.4	65.45	72.1	1.39
75.75	69.25	71.7	1.39
78.6	72.4	71.4	1.40
80.8	75.7	70.95	1.35
81.8	76.85	70.9	1.35
82.95	77.7	70.8	1.38
85.2	80.7	70.55	1.37
87.15	83.1	70.35	1.38
88.3	85.0	70.15	1.33
90.2	87.35	69.95	1.33
92.6	91.0	69.75	1.39
95.0	93.5	69.35	1.32
97.6	96.9	69.05	1.20
100.0	100.0	68.85	....

TABLE 12
Vapor-Liquid Equilibrium Data for the System Hexane - Methylcyclopentane Absolute Pressure = 760 MM HG

Mole Percent Hexane		Temperature, C	Relative Volatility, Alpha
Vapor	Liquid		
0.0	0.0	71.85	.....
3.5	2.5	71.75	1.41
9.8	8.15	71.55	1.22
14.2	12.3	71.4	1.18
18.8	16.8	71.2	1.15
24.8	22.2	71.0	1.16
30.0	27.3	70.85	1.14
35.3	32.6	70.65	1.13
35.9	33.4	70.6	1.12
39.0	35.9	70.5	1.14
42.4	39.3	70.4	1.14
42.2	39.6	70.35	1.11
43.8	41.5	70.3	1.10
46.2	43.0	70.25	1.14
47.2	45.0	70.2	1.09
50.2	47.6	70.1	1.11
51.65	49.3	70.05	1.10
56.25	53.2	69.95	1.13
57.1	54.7	69.9	1.10
62.3	60.5	69.75	1.08
64.8	62.6	69.7	1.10
68.5	66.6	69.6	1.09
69.2	67.9	69.55	1.06
75.6	74.0	69.4	1.09
77.4	75.8	69.35	1.09
82.0	81.1	69.2	1.06
84.5	83.3	69.15	1.09
85.4	84.5	69.1	1.07
89.1	88.2	69.05	1.09
93.4	92.5	68.9	1.14
100.0	100.0	68.75	.....

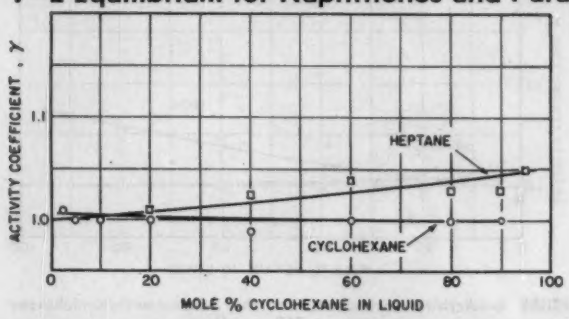


FIGURE 7—Activity coefficients for the heptane-cyclohexane system at 760 mm Hg.

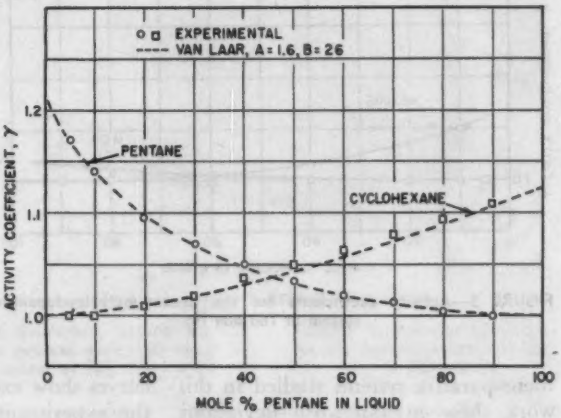


FIGURE 8—Activity coefficients for the pentane-cyclohexane system at 769 mm Hg.

azeotrope for hexane-benzene, based on a ternary distillation. The composition is given as 4.7 percent benzene with a boiling-point depression of 0.5 C. Lecat[6] also says that hexane-benzene forms an azeotrope. On the other hand, two earlier investigators[5,16] give boiling-point data for mixtures of hexane and benzene and show no minimum in the boiling-point curve. In addition, Tongberg and Johnston[15] give complete data for this system and show no azeotrope.

The present study of the benzene-heptane and hexane-benzene systems did not show any temperature depression that would prove the existence of an azeotrope. It appears that a very low relative-volatility, without azeotrope formation is characteristic of these two mixtures.

All of the data reported in this work, except for a few systems that are essentially ideal, were checked by one or more of the consistency equations. The Van Laar equations, as modified by Robinson and Gilliland[12] were preferred, because they include a temperature term.

Deviations of all of the isobaric data from the Van Laar and other consistency equations were greater than can be explained by analytical errors, and were greatest for the wide-boiling systems. When one of these wide-boiling systems, pentane-cyclohexane, was run isothermally in the same equipment, and using the same techniques, agreement with the Van Laar equation was excellent. This indicates that the consistency equations should be used with caution in checking isobaric data.

TABLE 13
Vapor-Liquid Equilibrium-Data for the System Hexane-Methylcyclohexane Pressure = 760 MM HG Absolute

Mole Percent Hexane		Temperature, C	Relative Volatility, Alpha
Vapor	Liquid		
0.0	0.0	100.95	.....
4.25	1.5	100.0	2.91
9.3	3.8	98.8	2.60
15.1	6.55	97.45	2.54
21.35	9.85	95.9	2.48
29.2	13.4	94.05	2.67
36.5	18.4	92.0	2.55
44.2	23.45	89.95	2.59
50.75	29.15	87.8	2.50
54.5	32.3	86.55	2.51
55.7	33.1	86.35	2.54
55.9	33.5	86.2	2.52
58.6	36.7	85.1	2.45
58.8	36.9	85.1	2.44
60.3	38.45	84.9	2.65
62.95	40.4	83.9	2.51
62.45	41.7	83.6	2.51
65.05	42.3	83.1	2.54
68.65	46.65	82.0	2.50
69.45	47.7	81.25	2.49
72.8	50.95	80.6	2.58
73.2	52.0	80.36	2.52
73.8	52.4	79.85	2.56
74.9	54.7	79.6	2.47
75.3	55.0	79.55	2.49
75.5	54.5	79.45	2.57
77.2	57.4	78.7	2.51
77.8	58.0	78.4	2.54
79.9	61.3	77.65	2.51
84.3	68.65	75.9	2.45
92.85	83.7	72.1	2.53
93.3	84.1	72.05	2.63
94.3	86.4	71.5	2.60
96.4	91.1	70.55	2.62
100.0	100.0	68.7	.....

TABLE 14
Vapor-Liquid Equilibrium Data for the System Cyclohexane-Heptane Absolute Pressure = 760 MM HG

Mole Percent Cyclohexane		Temperature, C	Relative Volatility, Alpha
Vapor	Liquid		
0.0	0.0	98.4	.....
3.6	1.6	97.9	2.30
8.2	5.1	97.1	1.66
11.75	7.75	96.5	1.58
16.3	11.05	95.9	1.57
25.05	16.4	94.6	1.71
26.05	18.2	94.3	1.58
38.75	19.55	94.0	1.66
30.05	21.25	93.8	1.59
31.7	22.0	93.55	1.64
33.0	23.0	93.3	1.65
40.65	29.1	92.1	1.67
45.05	33.0	91.35	1.67
51.1	38.95	90.3	1.64
57.25	44.8	89.3	1.65
59.1	46.45	89.0	1.66
61.65	49.8	88.35	1.62
66.25	54.6	87.5	1.63
70.2	58.25	86.75	1.69
73.6	62.55	86.15	1.67
79.8	70.2	85.0	1.68
84.2	76.3	84.0	1.66
89.6	83.35	83.05	1.72
93.7	89.8	82.2	1.69
96.25	93.7	81.65	1.73
98.3	97.3	81.1	1.60
100.0	100.0	80.7	.....

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About the Author

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For Fractionators . . .

Allowable Entrainment at Minimum Cost

Here is an empirical relationship which defines the entrainment rate at minimum fractionator cost.

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New York

MINIMUM-COST CRITERION in terms of allowable entrainment may soon replace the maximum allowable velocity concept in tower design. The minimum cost fractionator should have a design entrainment of 0.175 (L/V). Any tray design having a lower entrainment rate is probably not the most economical vessel for the specific capacity.

Since the publication of a paper by Souders and Brown[4] in 1934, in which they introduced the "maximum allowable velocity" concept into tower design, this criterion, with modifying coefficients represented as functions of tray spacing, has served industry almost unanimously. Its form in various organizations and in various applications has differed mainly in the functions and limits of the coefficients. The vast number of successfully operating fractionation units certainly attests to the adequacy of this method for tower sizing in the majority of cases. This is particularly true in the petroleum industry where large size caps and tray spacings of the order of 18 inches to 42 inches are common. The original work of Souders and Brown is based on such refinery installations. In recent years increasing competitive pressure stimulated more extensive quantitative studies of the entrainment of liquid from tray to tray. The anticipated reduction in tray efficiency due to added entrainment could presumably be estimated from Colburn's[1] relationship and thus an optimum or cheapest tower size defined. The following is an attempt to express the general problem analytically and arrive at some simple criteria for ascertaining whether a proposed design approaches a minimum-cost installation.

Colburn's equation relating the effect of liquid entrainment to tray efficiency is given as:

$$E_a = \frac{E_o}{1 + \frac{e\,E_o}{L/V}} \qquad (1)$$

where E_a = tray efficiency at entrainment rate of e
E_o = tray efficiency at zero or negligible entrainment
e = rate of liquid entrainment to tray above, lbs. liquid per lb. vapor
L = liquid downflow rate, lbs./hr.
V = vapor upflow rate, lbs./hr.

The zero or base case entrainment efficiency, E_o, is sometimes accepted as that obtained from the O'Connell[2] correlation. If a generalized entrainment relationship in terms of throughput and tray spacing were substituted for e in Equation (1) it should be possible to solve any design problem for the most economical tower.

If N_T = number of theoretical trays required for a desired separation,
then $N_T/E_o = N_o$, the number of actual trays required at zero entrainment,
and $N_T/E_a = N_a$, the number of actual trays required at some specific entrainment rate e.
Now $N_a - N_o = N_\Delta$, the number of additional trays required to offset the reduction in tray efficiency due to the entrainment,
or

$$N_\Delta = \frac{N_T}{E_a} - \frac{N_T}{E_o}$$

which can be rewritten as

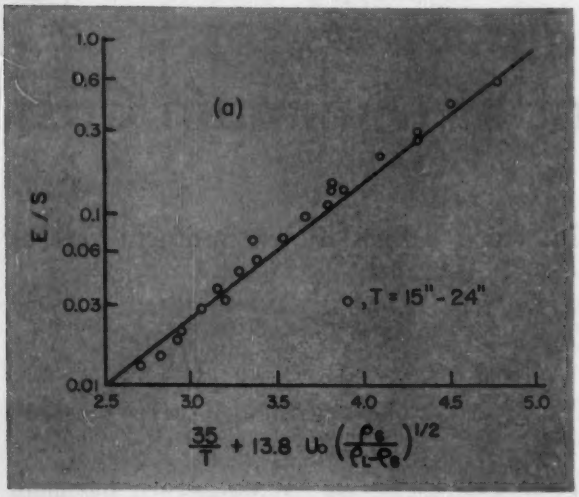
$$N_\Delta = N_T\left[\frac{1}{E_a} - \frac{1}{E_o}\right]$$

Multiplying through by E_o gives

About the Author

FREDERICK A. ZENZ is senior engineer for Walter Kidde Nuclear Laboratories, Inc. He received his B.S. degree from Queens College in 1942, and his M.S. degree in chemical engineering from New York University in 1950. He is presently completing the requirements for a Ph.D. degree in engineering science from Polytech Institute of Brooklyn. Zenz has had 14 years of varied process and development experience in the industry. He has published more than 20 papers on distillation and multiphase flow, including a chapter in the book on "Fluidization" edited by Othmer. He has been a lecturer on fluid flow in the graduate division of New York University, and has also done part-time consulting.

Allowable Entrainment at Minimum Cost...



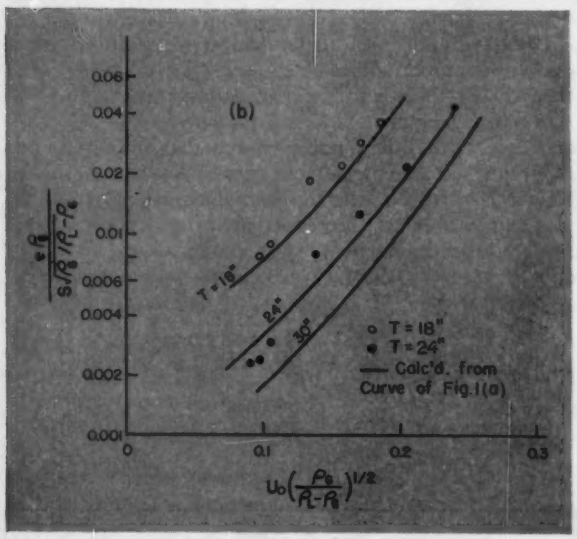


FIGURE 1A and 1B—Entrainment correlation of Simkin, Strand and Olney.[3]

Legend— T = Tray spacing, inches
E = Entrainment, pounds per minute per square foot
e = Entrainment, pounds per pound of vapor
U_o = Superficial vapor velocity, feet per second
ρ_g = Vapor density, pounds per cubic foot
ρ_L = Liquid density, pounds per cubic foot
S = Liquid submergence, inches (measured from bottom edge of operating slot opening)

$$N_\Delta E_o = N_T\left[\frac{1}{E_o/E_o} - 1\right] \qquad (2)$$

The Colburn Equation, (1), can also be written

$$\frac{E_o}{E_o} = \frac{1}{e\left(\frac{E_o}{L/V}\right)+1} \qquad (3)$$

Substituting (3) into (2):

$$N_\Delta E_o = N_T\left[\ e\ \left(\frac{E_o}{L/V}\right)\right]$$

and simplifying:

$$\frac{e}{L/V} = \frac{N_\Delta}{N_T} \qquad (4)$$

Process conditions fix the values of L/V, and N_T.

Equation (4) therefore defines the relation between entrainment and the number of additional trays required to offset the accompanying reduction in tray efficiency.

To a fairly good first approximation the major portion of the cost of a tower can be expressed simply as shell cost plus tray cost:

$$\text{Cost, \$} = (\text{Price per tray}) \times (\text{Number of trays}) + (\text{Price per foot of shell}) \times (\text{Tower height}) \qquad (5)$$

The expression ignores erection, foundation, structural supports, insulation, nozzles, manholes, etc., but nevertheless expresses the bulk cost sufficiently for a general comparison of alternate designs. If the tray cost be expressed in terms of dollars per square foot of tray surface, and shell cost in terms of dollars per pound, Equation (5) can be written:

$$\text{Cost, \$} = (\$/\text{ft.}^2)\frac{\pi D_T^2}{4}\left[\frac{N_T}{E_o} + N_\Delta\right] + (\$/\text{lb.})\,\frac{\pi D_T t\, T \rho_s}{12}\left[\frac{N_T}{E_o} + N_\Delta\right] \qquad (6)$$

where: D_T = tower diameter, feet
T = tray spacing, inches
t = shell thickness, feet
ρ_s = metal density, lbs./cu. ft.

The bracketed terms in Equation (6) can be rewritten as

$$\left[\frac{N_T}{E_o} + N_\Delta\right] = N_T\left[\frac{1}{E_o} + \frac{N_\Delta}{N_T}\right] \qquad (7)$$

and the value of N_Δ/N_T as obtained from (4) substituted in (7):

$$\left[\frac{N_T}{E_o} + N_\Delta\right] = N_T\left[\frac{1}{E_o} + \frac{e}{L/V}\right] \qquad (8)$$

Substituting (8) back into (6) and dividing through by N_T:

$$\frac{\text{Cost, \$}}{N_T} = \left[\frac{1}{E_o} + \frac{e}{L/V}\right]\left[\frac{\pi D_T^2}{4}(\$/\text{ft.}^2) + \frac{\pi D_T t\, T \rho_s}{12}(\$/\text{lb.})\right] \qquad (9)$$

If a function relating e to the tower loading and tray spacing were substituted in Equation (9) it would be possible to compute a curve of cost, $\$/N_T$ versus D_T and arrive at the minimum-cost tower size. Simkin et. al.[3] recently published such a function shown graphically in Figures 1(a) and 1(b). They fitted an empirical equation to their data of the form:

$$e = \left[\frac{S}{60\rho_G U_o}\right] \times 10^{-3.95 + \frac{27.3}{T} + 10.75\, U_o\left(\frac{\rho_G}{\rho_L - \rho_G}\right)^{0.5}} \qquad (10)$$

where: e = liquid entrainment, lbs./lb. vapor
ρ_G = vapor density, lbs./cu. ft.
ρ_L = liquid density, lbs./cu. ft.
T = tray spacing, inches
U_o = superficial tower vapor velocity in free area, ft./sec.
S = vapor submergence from bottom of slot to liquid surface, inches

Replacing e in (9) with its analytical expression (10) yields a rather unwieldy expression having apparently too many variables for simple graphical presentation. As an alternative, several cases were calculated to investigate the effects of the major variables. The first six columns of Table 1 indicate the magnitudes of these variables in the seven cases investigated. Since liquid density enters Equation (10) to the 0.5 power this quantity was held constant; an average value of 40 pounds per cubic foot was chosen. The tray free area

was conservatively taken as 70 percent of the tower cross sectional area, tray cost at $12 per square foot, and shell cost at from 40 to 50 cents per pound depending on the diameter.

Figure 2 presents schematically the sort of curves resulting from the solution of Equation (9) and (10) for any of the seven cases investigated. From such curves the values of e_m at the minimum-cost points were obtained and tabulated in column eight of Table 1. These values were then substituted in Equation (4) to estimate the values of N_Δ/N_T at minimum tower cost. This ratio was found to be a constant equal to 0.175. In other words if the number of additional trays, N_Δ, provided to overcome the effects of entrainment, equals about 17.5 percent of the number of theoretical trays required, then the optimum total number of trays has been provided and the limit of entrainment in design at those conditions can be obtained from Equation (4) or (11) as:

$$e_m = 0.175\ (L/V) \qquad (11)$$

Since process consideration fix L/V, Equation (11) gives the entrainment limit to which trays should be pushed in order to approach minimum tower cost. The corresponding total number of trays required is $N_T[(1/E_o + 0.175]$.

Equation (11) appears to be independent of the absolute level of the entrainment rate. Figure 3 presents the results for cases 6 and 7 of Table 1; case seven is identical to six except that the level of the entrainment rate is one-tenth that of case six, or approximately the level indicated for conventional perforated plates or grid trays. In Figure 3 the lower entrainment level calculations were adjusted in tray-area-cost to coincide with perforated plate installations. Equation (11) still applies at the minima. Note that the use of perforated plates indicates approximately 16 percent attainable reduction in tower diameter (or about 35 percent reduction in tray area) and about 30 percent reduction in bare tower cost.

In computing the curves in Figures 2 and 3 no consideration was taken of capacity limitations imposed by liquid backup or tower flooding. In general it would not be possible to approach the minimum-cost diameters at 18-inch tray spacing without flooding. However, the minima can be attained at 24-inch and/or 30-inch tray spacings in nearly every case.

In comparing the minimum tower diameters calculated from Souders and Brown's original curves, with each of the cases investigated here, it was found that their maximum allowable velocity limitations correspond to values of e of 0.02 to 0.04 (when e is defined by Equation 10). Equation (11) would indicate minimum-cost values to be nearly 10 times as great in most instances.

Quantitative conclusions regarding actual minimum-cost tower sizes should not be considered applicable beyond the limitations of Equation (10). Equation (10) should not be used to calculate entrainment from caps smaller than 3-inch nominal size, nor for liquid rates exceeding 300 GPH per inch of weir, or submergences greater than 3 inches above the top of the slots.

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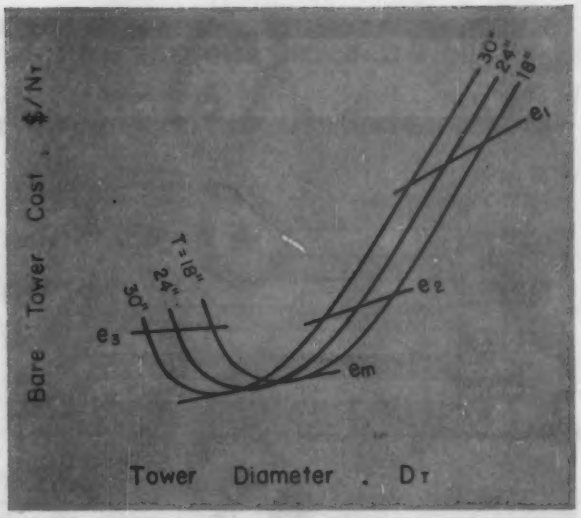


FIGURE 2—Schematic illustration of solution of Equations (9) and (10) at fixed throughput. e_m Entrainment at minimum cost; e_1, e_2, e_3, indicating increased entrainment.

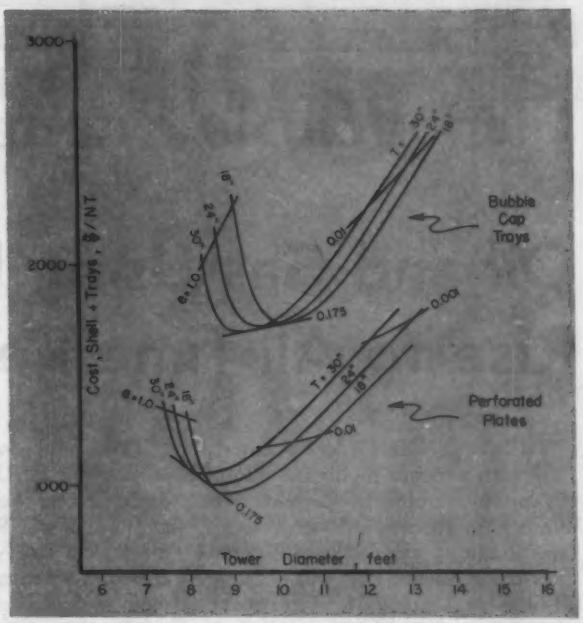


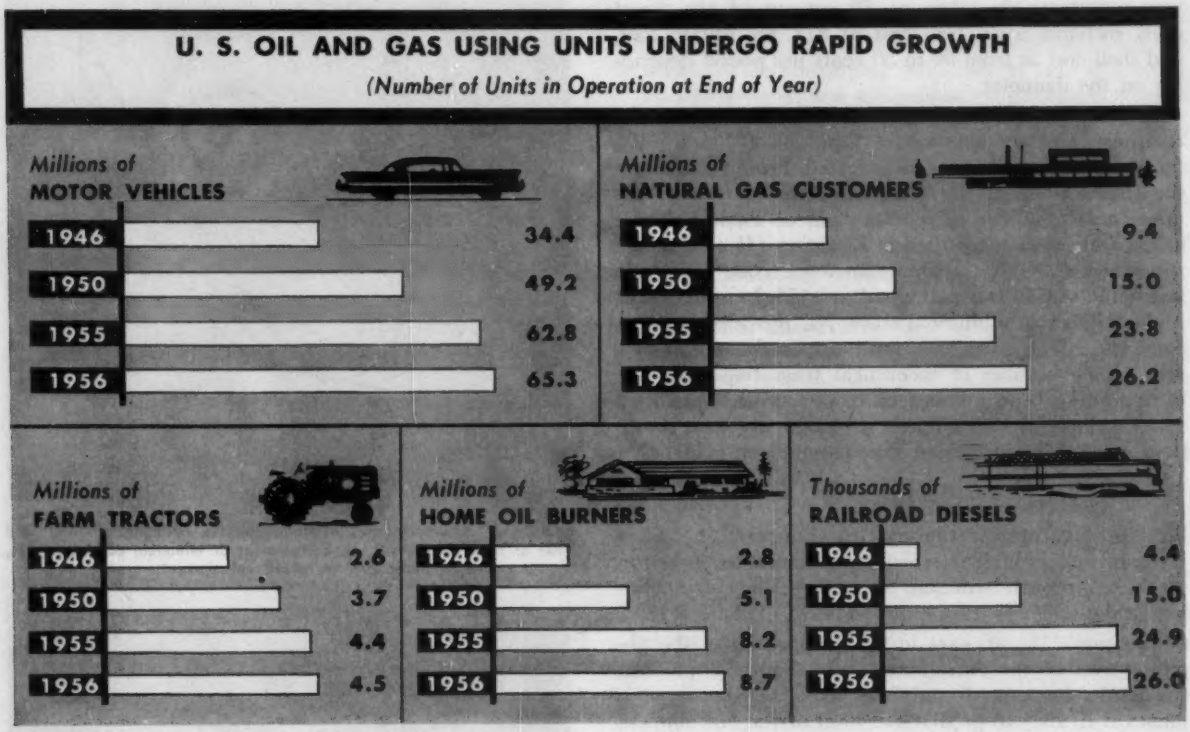
FIGURE 3—Typical cost and capacity comparison between perforated plates and bubble cap trays. (1954 dollars) Effect of absolute entrainment level—Cases 6 and 7 of Table 1.

TABLE 1

Ranges of Variables Investigated in the Solutions of Equations (9) and (10)

Case	Vapor Rate CFS	L/V	E_o	ρ_G	S	ρ_L	e_m*	$\left(\frac{N_\Delta}{N_T}\right)_m$†
1	100	1	0.8	1.0	3	40	0.175	0.175
2	100	2	0.5	1.0	3	40	0.35	0.175
3	100	1	0.5	1.0	3	40	0.175	0.175
4	50	1	0.8	1.0	3	40	0.175	0.175
5	100	0.5	0.8	1.0	3	40	0.087	0.175
6	200	1	0.8	0.25	3	40	0.175	0.175
7	200	1	0.8	0.25	0.3	40	0.175	0.175

* e_m, entrainment rate for minimum-cost installation at 30" tray spacing.
† $(N_\Delta/N_T)_m$, from equation (4), $e_m/(L/V)$.



Oil and Gas Using Units Rise to All-Time Peak

THE UNITED STATES entered 1957 with a record number of oil and gas consuming units in operation. The number of homes, motor vehicles, farm tractors, and railroad locomotives using oil and gas will be at an all-time peak in 1957. Therefore, more oil and gas is expected to be consumed than ever before.

It is significant that the rate of growth showed relatively little change from the high level that has prevailed in recent years. All signs indicate additional growth will take place during 1957.

Motor Vehicles in the U. S. rose to a new peak of 65.3 million at the end of 1956. This represented a gain of 2.5 million during the past year, compared with a gain of 4.2 million during 1955. These figures are for all types of motor vehicles, passenger cars, trucks and buses.

There has been a very sharp growth in number of U. S. motor vehicles during recent years. The 65.3 million at the end of 1955 was 16.1 million more than five years ago, or almost one-third greater. The number of motor vehicles has almost doubled in the last 10 years, currently being 30.9 million above the 34.4 million in operation at the end of 1956.

Natural Gas Customers have undergone an especially sharp growth in the U. S. during recent years. At the end of 1956 there were 26.2 million natural gas customers, a gain of 2.4 million over the previous year. This was a much greater rate of growth than during 1955, when there were 1.7 million new natural gas customers.

Five years ago there were only 15.0 million natural gas customers in the U. S., 11.2 million less than today. Ten years ago there were but 9.5 million natural gas customers, 16.8 million fewer than at the end of 1956.

Residential customers make up the bulk of natural gas customers. In totaling 24.1 million at the end of 1956, residential gas customers rose 10 percent from the 21.9 million at the end of 1955.

Home Oil Burners climbed to a new peak of 8.7 million at the end of 1956. This was half a million more than a year ago, the smallest rate of growth in years. Five years ago there were only 5.1 million home burners, while 10 years ago there were but 2.8 million.

Farm Tractors advanced to a total of 4.5 million by the end of 1956. This was an increase of only 100,000 from a year ago, while 1955 had recorded a gain of 150,000. Ten years ago there were only 2.6 million farm tractors in the U. S., and five years ago there were but 3.7 million.

Railroad Diesel Locomotives reached a new peak of 26.0 million at the end of 1956, compared with 24.9 million a year before. Ten years ago there were only 4.4 million railroad locomotives. ##

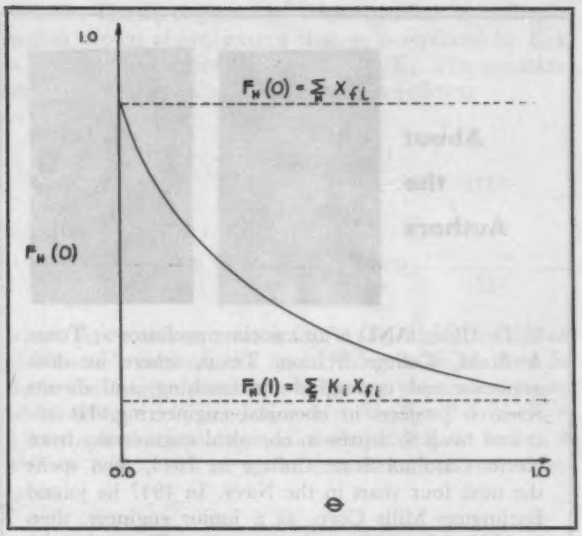


FIGURE 1—Graphical representation of the function $F_H(\Theta)$.

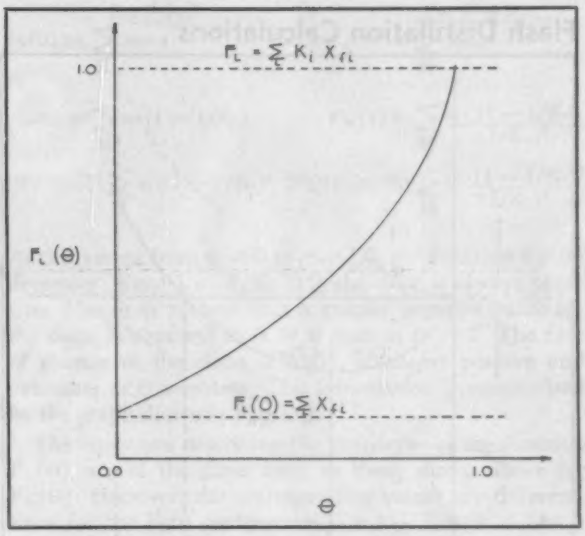


FIGURE 2—Graphical representation of the function $F_L(\Theta)$.

Simplify Flash Distillation Calculations

This method is in a good form for digital computer calculations.

C. D. Holland and R. R. Davison
Texas A&M College
College Station, Texas

THIS METHOD is based on the rearrangement of the flash equation from the usual form to one containing only one of the two possible variables, L and V. With the equation in this form, it is readily solved by the use of Newton's method.[7] The application of this method is shown by the solution of two illustrative examples. In the past several methods of merit for solving the flash equation have been proposed.[2, 3, 4, 5, 6] However, it is believed that the present method surpasses these in ease of application.

Statement of Equations

A general development of the flash equation is shown below. This development includes the case where the feed contains non-condensable gases as well as volatile components. Although a non-condensable gas is a single phase component, it may, for convenience, be treated as a two phase component by making its Henry's law constant, K, very large. For the case where the insert gas phase component is condensable (steam, for example), a treatment is given in an article to appear in a future issue of PETROLEUM REFINER.

At equilibrium, when the flash temperature and pressure are specified such that a two phase mixture exists, the material balance for component "i" is

$$F_t X_{fi} = V_t y_i + L x_i \tag{1}$$

where, $F_t = F + V_s$ = moles of feed plus the moles of non-condensable gases. $V_t = V + V_s$ = moles of vapor formed plus the moles of non-condensable gases.

When Henry's law is applicable,

$$F_t X_{fi} = V_t y_i + \frac{L y_i}{K_i} \tag{2}$$

Then,

$$y_i = \frac{F_t X_{fi}}{V_t + \frac{L}{K_i}} = \frac{F_t X_{fi}}{F_t - L + \frac{L}{K_i}}, \tag{3}$$

since $F_t = V_t + L$.

Upon dividing both numerator and denominator by F_t and rearranging, one obtains

$$y_i = \frac{X_{fi}}{1 - \frac{L}{F_t}\left(1 - \frac{1}{K_i}\right)} \tag{4}$$

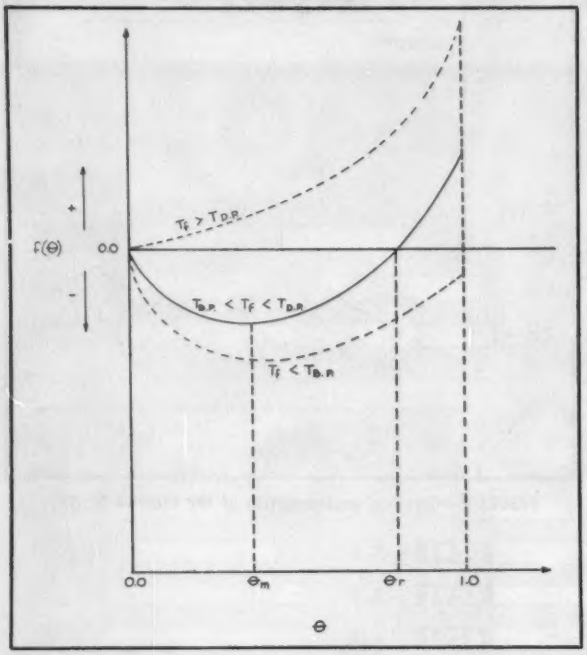


FIGURE 3—Graphical representation of the function f (Θ).

The sum over all components of both sides of equation (4) is

$$1 = \sum_{i=1}^{c} \frac{X_{fi}}{1 - \frac{L}{F_t}\left(1 - \frac{1}{K_i}\right)} \tag{5}$$

Now for convenience, let L/F_t be denoted by Θ, and let the function $f(\Theta)$ be defined as follows:

$$f(\Theta) = \sum_{i=1}^{c} \frac{X_{fi}}{1 - \Theta\left(1 - \frac{1}{K_i}\right)} - 1 \tag{6}$$

A solution of this equation is obtained when a value of Θ is selected which gives $f(\Theta) = 0$. The trial and error is reduced by the use of Newton's method.[7] This method consists of the repeated use of the first two terms of a Taylor series for the function $f(\Theta)$. The first two terms of the series expansion of $f(\Theta)$ about some value of Θ, say Θ_a, are as follows:

$$f(\Theta) = f(\Theta_a) + (\Theta - \Theta_a)\, f'(\Theta_a) \tag{7}$$

This is an approximation of $f(\Theta)$, since only the first two terms of the expansion are used. Now let $\Theta = \Theta_r$, the desired root of the flash equation. Then $f(\Theta_r) = 0$, and equation (7) reduces to

$$\Theta_r = \Theta_a - \frac{f(\Theta_a)}{f'(\Theta_a)} \tag{8}$$

where $f(\Theta_a)$ and $f'(\Theta_a)$ are the values of the function and its first derivative at $\Theta = \Theta_a$. They are as follows:

$$f(\Theta_a) = \sum_{i=1}^{c} \frac{X_{fi}}{1 - \Theta_a\left(1 - \frac{1}{K_i}\right)} - 1 \tag{9}$$

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$$f'(\Theta_a) = \sum_{i=1}^{c} \frac{X_{fi}\left(1 - \frac{1}{K_i}\right)}{\left[1 - \Theta_a\left(1 - \frac{1}{K_i}\right)\right]^2} \tag{10}$$

In the calculational procedure, Θ_a becomes the assumed value of the root, Θ_r. Using the assumed value of the root, $f(\Theta_a)$ and $f'(\Theta_a)$ are calculated. Then, a more correct value for Θ_r is obtained by use of equation (8). The value obtained is used as the assumed value for the next trial. This procedure is repeated until a value of Θ_r of sufficient accuracy is obtained.

The function $f(\Theta)$ has c roots. Only two of these have physical significance, the value $\Theta = 0$ and the desired root $\Theta = \Theta_r$. As is shown in the next section, Newton's method will always converge to the desired root, Θ_r, if the largest possible physical value of Θ is selected as the first assumed value of Θ_a. For a mixture containing noncondensable gases and for a mixture free of them, the largest possible physical values are $\Theta_a = F/F_t$ and $\Theta_a = 1.0$, respectively. These are the values corresponding to $V = 0$.

If one had to solve a large number of problems where most of the feed is vaporized in the flash process, the equation resulting from having selected V_t as the independent variable would require fewer trials than those shown above, where L was selected as the independent

variable. The development of these equations is analogous to that shown above, except that y_i is replaced by $K_i x_i$ in equation (2) instead of x_i = by y_i/K_i. The equations corresponding to (9) and (10) are as follows:

$$f(\Phi_a) = \sum_{i=1}^{c} \frac{X_{fi}}{1-\Phi_a(1-K_i)} - 1 \qquad (11)$$

$$f'(\Phi_a) = \sum_{i=1}^{c} \frac{X_{fi}(1-K_i)}{[1-\Phi_a(1-K_i)]^2} \qquad (12)$$

where Φ_a = assumed value for V_t/F_t. Again, in the use of Newton's method, the initial value to be assumed for Φ_a is the largest possible one having physical meaning, which is $\Phi_a = 1.0$, since $\Phi_a = V + V_a/F_t = F + V_a/F_t = 1.0$ for a feed containing non-condensable gases and $\Phi_a = V/F = F/F = 1.0$ for a feed containing no non-condensables.

Examination of the Function f(Θ)

To simplify the examination, a mixture free of non-condensable gases is selected; that is $F_t = F$, $V_t = V$, $X_f = x_f$ and $\Theta = L/F$. The function $f(\Theta)$ has physical meaning when the flash temperature is greater than the boiling point and less than the dew point of the feed at the specified pressure of the flash. Thus the physical limitations require that

$$0 < \Theta < 1.0$$

The concept of light and heavy components is used in the following discussion. A light component is by definition one for which $1/K_i \leqq 1$, and a heavy component one for which $1/K_i > 1$. For the range of values between $\Theta = 0$ and $\Theta = 1$, each term in the summation of the function $f(\Theta)$ should be positive, since each term represents a y_i. Namely,

$$y_i = \frac{x_{fi}}{1-\Theta\left(1-\frac{1}{K_i}\right)} = \frac{x_{fi}}{1-\frac{L}{F}\left(1-\frac{1}{K_i}\right)}$$

Since $F > L$, the denominator of the expression for y_i is always positive and the expression therefore gives positive values for y for all values of Θ in the range of $0 < \Theta < 1$. Since $(1 - 1/K_i)$ may be either positive or negative depending upon whether or not i represents a light or heavy component, respectively, it is desirable to consider the lights and heavies separately in the examination of the function $f(\Theta)$. More specifically, let

$$F_H(\Theta) = \sum_{H} \frac{x_{fi}}{1-\Theta\left(1-\frac{1}{K_i}\right)}$$

$$F_L(\Theta) = \sum_{L} \frac{x_{fi}}{1-\Theta\left(1-\frac{1}{K_i}\right)}$$

where H refers to all components for which $1/K_i > 1$ and L to those for which $1/K_i \leqq 1$. These functions are related to the original function $f(\Theta)$ in the following manner:

$$f(\Theta) = F_H(\Theta) + F_L(\Theta) - 1$$

The values of the function $F_H(\Theta)$ and its derivatives at $\Theta = 0$ and $\Theta = 1$ are as follows:

For $\Theta = 0$	For $\Theta = 1$
$F_H(0) = \sum_H x_{fi}$	$F_H(1) = \sum_H K_i x_{fi}$
$F'_H(0) = \sum_H x_{fi}(1 - 1/K_i)$	$F'_H(1) = \sum_H \frac{x_{fi}(1-1/K_i)}{(1/K_i)^2}$
$F''_H(0) = (2)\sum_H x_{fi}(1 - 1/K_i)^2$	$F''_H(1) = (2)\sum_H \frac{x_{fi}(1-1/K_i)^2}{(1/K_i)^2}$

As Θ is varied from $\Theta = 0$ to $\Theta = 1.0$, the function $F_H(\Theta)$ decreases. Since $1 - 1/K_i \leqq 0$, the slope is always negative. Also, it is evident that a greater negative value for the slope is obtained at $\Theta = 0$ than at $\Theta = 1$. The rate of change of the slope, $F''_H(\Theta)$, is always positive and decreases as Θ increases. This information is summarized by the graph shown in Figure 1.

The equations describing the properties of the function $F_L(\Theta)$ are of the same form as those shown above for $F_H(\Theta)$. However, the corresponding values are different, since for the light components $0 \leqq 1 - 1/K_i < 1$. As Θ is varied from 0 to 1.0, the function $F_L(\Theta)$ increases from

$$\sum_L x_{fi} \text{ to } \sum_L K_i x_{fi}.$$

Its slope is always positive and increases as Θ increases. The rate of change of the slope also increases as Θ increases. These properties are illustrated by the graph of the function $F_L(\Theta)$, Figure 2.

It is to be observed that one real root of the function $f(\Theta)$ is $\Theta = 0$, which gives

$$f(\Theta) = \sum_i x_{fi} - 1 = 0.$$

An examination of Figures 1 and 2 (or the corresponding functions $F_H(\Theta)$ and $F_L(\Theta)$) shows that the necessary conditions for another root to lie between $\Theta = 0$ and $\Theta = 1$ are as follows:

$$F_H(1) + F_L(1) > 1 \text{ and } |F_H|(0)| > |F'_L(0)|$$

where the vertical lines are used to denote the magnitudes of the quantities enclosed. The above conditions are satisfied when the flash temperature lies between the bubble point and dew point of the feed at the specified pressure. A plot of the function $f(\Theta)$ is shown in Figure 3. For two-phase mixtures, the slope of the curve in the region where Θ approaches 1.0 is primarily dependent on $F'_L(\Theta)$. Thus, the slope of $f(\Theta)$ changes from a negative to a positive value as Θ goes from 0 to 1.0, and therefore the function $f(\Theta)$ possesses a minimum. Since $f(0) = 0$, and since $f'(0)$ is equal to a negative number, the curve has the form shown in Figure 3. The most important point illustrated by this plot is that the desired root of the flash equation, Θ_r, is greater than Θ_m and less than 1.0. If a value of $\Theta_a = 1.0$ is taken as the initial assumption (except for the case of a single phase component in the gas phase, where $\Theta_a = F/F_t$ is suggested), Newton's method converges to the desired root, Θ_r, since $f(\Theta)$, $f'(\Theta)$ and $f''(\Theta)$ are positive throughout the range $\Theta = 1$ to $\Theta = \Theta_r$. This follows from equation (8), since the corrected value of Θ is always less than the previously assumed value. If a value of $\Theta_a < \Theta_m$ were taken for the initially assumed value of the root, then the application of Newton's method would lead to the root $\Theta = 0$, since for $0 \leqq \Theta < \Theta_m$, $f(\Theta) < 0$ and $f'(\Theta) < 0$. In addition

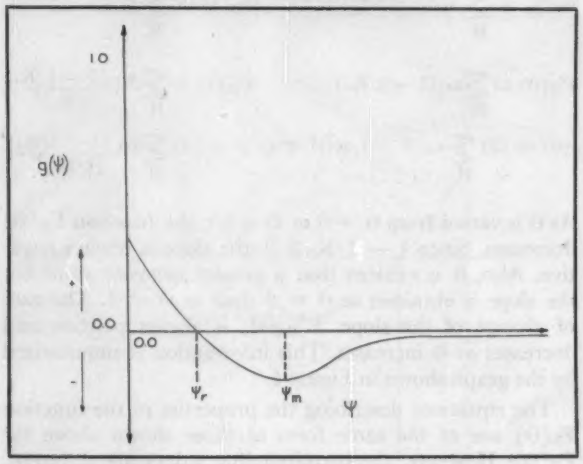

FIGURE 4—Plot of the function $g(\psi)$.

to the roots $\Theta = 0$ and $\Theta = \Theta_r$, the flash equation has $c - 2$ other roots. These are not of physical significance and were therefore omitted in the plot of the function $f(\Theta)$.

As a matter of interest, sketches of the function $f(\Theta)$ are shown for the cases where $T_f > T_{D.P.}$ and $T_f < T_{B.P.}$ T_f refers to the flash temperature and $T_{D.P.}$ and $T_{B.P.}$, the dew point and bubble point temperatures, respectively. It is to be observed that in each case, one of the necessary conditions for a root to lie between $\Theta = 0$ and $\Theta = 1$ is not satisfied.

When the feed contains some non-condensable gases, the arguments are the same as those presented except that the upper limit of Θ is F/F_t instead of 1.0.

The above equations are also applicable when the feed F contains soluble non-volatile components, since for $K_i = 0$, the expression for y_i gives $y_i = 0$. The non-volatile components would of course alter x_{fi}, X_{fi}, and x_i, since it was specified that these components were soluble in the volatile components.

The flash equation may be expressed in terms of L/V and V/F as shown by Brown and Associates.[1] Since V/F may be stated in terms of L/V, the flash equation may be expressed as a function of L/V. This equation may be written

$$g(\psi) = \sum_{i=1}^{c} \frac{x_{fi}}{K_i + \psi} - \frac{1}{1+\psi}$$

where $\Psi = L/V$. A graph of this function for positive values of Ψ is shown in Figure 4. This form of the flash equation may in some cases prove inconvenient since the values of Ψ which are possible for a physical system range from zero to infinity. If one were to employ Newton's method to solve for the desired root, Ψ_r, one should take $\Psi_a = 0$ for the first assumed value of the root. In a cut and try calculation, $g(\Psi)$ represents V/F (calculated) minus V/F (assumed). It is evident from the graph of $g(\Psi)$ that if in a cut and try procedure one by chance selected a value of $\Psi > \Psi_m$ as the assumed value of L/V, one would tend to choose larger and larger values of Ψ and observe that in so doing $g(\Psi)$ tended to zero in the limit. In view of this, it is no wonder that difficulties have arisen in the solution of the flash equation.

Illustrative Examples

The first example, consisting of a hydrocarbon feed, was selected from Brown and Associates.[1] Instead of using a flash temperature of 110 F., employed by these authors, a temperature of 150 F. was selected for the purpose of making the problem more difficult to solve by using equations (9) and (10). For their problem $\Theta_r = L/F = 0.93$; whereas for the modified form of the problem, a value of 0.457 was obtained. The statement and solution of this example is shown in Table 1. The detail steps are shown for the first trial, and for the remainder of the trials, the final results are shown. The rapidity

TABLE 1—Statement and Solution of Example 1

Statement			Solution					
F = 1.0 mole			First Trial: $\Theta_a = 1.0$					
COMPONENT	x_f	K* at 150° F. 50 psia	1-1/K	$\Theta_a(1-1/K)$	$1-\Theta_a(1-1/K)$	$y = \frac{x_f}{1-\Theta_a(1-1/K)}$	$\frac{x_f(1-1/K)}{1-\Theta_a(1-1/K)}$	$\frac{x_f(1-1/K)}{[1-\Theta_a(1-1/K)]^2}$
C_2	0.0079	16.2	0.9383	0.9383	0.0617	0.1280	0.1201	1.9465
C_3	0.1321	5.2	0.8077	0.8077	0.1923	0.6869	0.5548	2.8851
iC_4	0.0849	2.6	0.6154	0.6154	0.3846	0.2207	0.1358	0.3531
nC_4	0.2690	1.98	0.4949	0.4949	0.5051	0.5326	0.2636	0.5219
iC_5	0.0589	0.91	−0.0989	−0.0989	1.0989	0.0536	−0.0054	−0.0049
nC_5	0.1321	0.72	−0.3889	−0.3889	1.3889	0.0951	−0.0370	−0.0266
C_6	0.3151	0.28	−2.5714	−2.5714	3.5714	0.0882	−0.2268	−0.0635
						1.8051		$f'(\Theta_a) = 5.6116$
						−1.0000		
						$f(\Theta_a) = 0.8051$		

$$\Theta_r = 1.0 - \frac{0.8051}{5.6116} = 0.8565$$

Second Trial: $\Theta_a = 0.8565$

Results: $f(\Theta_a) = 0.3671$; $f'(\Theta_a) = 1.8370$; $\Theta_r = 0.8565 - \frac{0.3671}{1.8372} = 0.6567$

Third Trial: $\Theta_a = 0.6567$

Results: $f(\Theta_a) = 0.1206$; $f'(\Theta_a) = 0.8237$; $\Theta_r = 0.5102$

Fourth Trial: $\Theta_a = 0.5102$

Results: $f(\Theta_a) = 0.0261$, $f'(\Theta_a) = 0.4927$; $\Theta_r = 0.4573$

The value $\Theta_r = 0.4573$ is of sufficient accuracy, since the previous value of $\Theta_r = 0.510\,2$ gave $f(\Theta_a) = \sum_i y_{f-1} = 0.0261$. Actually a fifth trial based on $\Theta_a = 0.4573$ gave $f(\Theta_a) = \sum_i y_{f-1} = 0.00247$, and the corrected value for Θ was 0.4511.

* The values of the K's were taken from the Fifth Edition of the Technical Manual prepared by the Natural Gasoline Supply Men's Association.

TABLE 2—Statement and Solution of Example No. 2

Statement			Solution					
F = 1.0; Ft = 1.25			Fifth Trial $\Theta_a = 0.1884$					
COMPONENT	xf	K at 150° F. 50 psia	1-1/K	$\Theta_a(1-1/K)$	$1-\Theta_a(1-1/K)$	$y = \frac{X_f}{1-\Theta_a(1-1/K)}$	$\frac{X_f(1-1/K)}{1-\Theta_a(1-1/K)}$	$\frac{X_f(1-1/K)}{[1-\Theta_a(1-1/K)]^2}$
Non-condensable	0.2000	....	1.0	0.1884	0.8116	0.2464	0.2464	0.3036
C_2	0.0063	16.2	0.9383	0.1768	0.8232	0.0076	0.0071	0.0086
C_3	0.1057	5.2	0.8077	0.1522	0.8478	0.1247	0.1007	0.1188
iC_4	0.0679	2.6	0.6154	0.1159	0.8841	0.0768	0.0473	0.0535
nC_4	0.2152	1.98	0.4949	0.0932	0.9068	0.2373	0.1174	0.1295
iC_5	0.0471	0.91	−0.0989	−0.0186	1.0186	−0.0462	−0.0046	−0.0045
nC_5	0.1057	0.72	−0.3889	−0.0733	1.0733	−0.0985	−0.0383	−0.0357
C_6	0.2521	0.28	−2.5714	−0.4845	1.4845	−0.1698	−0.4366	−0.2941

First Trial: $\Theta_a = \frac{F}{F_t} = \frac{1}{1.25} = 0.8$

Results: $f(\Theta_a) = 1.0207$; $f'(\Theta_a) = 6.1336$; $\Theta_r = 0.8 - \frac{1.0207}{6.1336} = 0.6336$

Second Trial: $\Theta_a = 0.6336$

Results: $f(\Theta_a) = 0.4276$; $f'(\Theta_a) = 2.0977$; $\Theta_r = 0.4297$

$f'(\Theta_a) = 0.2797$

$-\frac{1.0074}{1.0000}$

$f(\Theta_a) = 0.0074$

$\Theta_r = 0.1884 - \frac{0.0074}{0.2797} = 0.1619$

Third Trial: $\Theta_a = 0.4297$

Results: $f(\Theta_a) = 0.1443$; $f'(\Theta_a) = 0.9001$; $\Theta_r = 0.2694$

Fourth Trial: $\Theta_a = 0.2694$

Results: $f(\Theta_a) = 0.0375$; $f'(\Theta_a) = 0.4622$; $\Theta_r = 0.1884$

with which the method converges to the correct value of Θ_r is evident.

The second example and its solution is shown in Table 2. This example was formulated by adding 0.25 moles of a non-condensable gas to one mole of hydrocarbons having the same composition as shown in example 1. Beginning with a value of $\Theta_a = F/F_t = 0.8$, the method gave $\Theta_r = L/F_t = 0.162$ and $\Sigma y_i - 1 = 0.0074$ in five trials. Fewer trials would have been required had equations (11) and (12) been employed. This is evident since the first value of $\Phi_a = 1.0$ is relatively close to the desired root $\Phi_r = 0.838$ (this is the value of Φ_r corresponding to $\Theta_r = 0.162$). Equations (11) and (12) were not used because it was desired to illustrate the rapidity with which the method converges when the initial value taken for Θ_a is far removed from the desired root Θ_r.

Conclusions

The method presented is easy to apply, and it converges rapidly to the desired root of the flash equation. The program of this method for a digital computer calculation is a simple one. The method, a systematic straightforward calculational procedure, should conserve the time of those who make flash calculations.

NOTATION

F = moles of feed entering the flash zone per unit time. Contains all components except non-condensable gases.

$F_t = F + V_a$, where V_a is defined below.

$f(\Theta)$ = function of $\Theta = L/F_t$; defined by equation (6). $f'(\Theta)$ = first derivative of $f(\Theta)$.

$F_H(\Theta), F_L(\Theta)$ = function of Θ, defined by equations (11) and (12). $F'_H(\Theta)$, $F''_H(\Theta)$, $F'_L(\Theta)$ and $F''_L(\Theta)$ = first and second derivatives of the functions $F_H(\Theta)$ and $F_L(\Theta)$, respectively.

$f(\Phi)$ = function of V_t/F_t; $f'(\Phi)$ = first derivative of $f(\Phi)$; see equations (9) and (10).

$g(\psi)$ = function of L/V; see context.

K = constant of Henry's law, $y = Kx$.

L = moles of liquid produced from F per unit time.

$T_f, T_{B.P.}, T_{D.P.}$ = flash, bubble and dew point temperatures of the total feed F_t at the specified pressure.

V = voles of vapor produced from F per unit time: $F = V + L$.

$V_t = V + V_a$ = total vapor leaving the flash zone per unit time.

V_a = moles of non-condensable gases entering with the feed F and leaving with the vapor V per unit time.

x = mole fraction of any component in the liquid L.

x_f = mole fraction of any component in the feed F.

X_f = mole fraction of any component in the feed F_t, $X_f = \frac{Fx_f}{F_t}$ for all component in F. For the non-condensable gases, $X_f = V_a/F_t$.

y = mole fraction of any component in the total vapor, V_t.

GREEK LETTERS

$\Theta = L/F_t$. When $V_a = 0$, $\Theta = L/F$. Θ_a = assumed value for the desired root, Θ_r, of the flash equation. Θ_m = value of Θ for which $f'(\Theta) = 0$.

$\sum_{i=1}^{c}$ = sum over all components from $i = 1$ to $i = c$, the total number of components. $\sum_H$ = sum over all components for which $1/K > 1$; and $\sum_L$ = sum over all components for which $1/K \leqq 1$.

$\Phi = V_t/F_t$. Φ_a = assumed value for Φ.

$\psi = L/V$, ψ_r = value of x which gives $g(\psi) = 0$; ψ_m = value of ψ for which $g'(\psi) = 0$.

OTHER SYMBOLS

$\geqq$ = equal to or greater than.

$\leqq$ = equal to or less than.

$>$ = greater than.

$<$ = less than.

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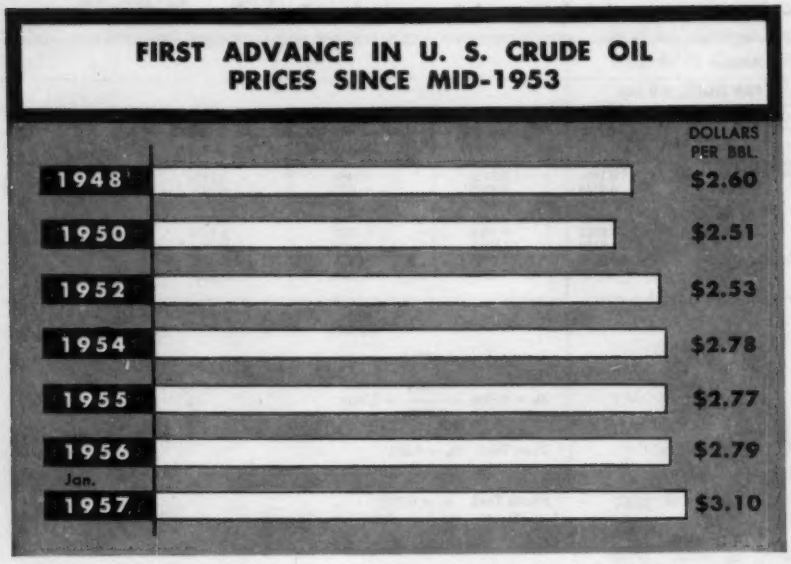

Crude Oil Prices Rise, Mideast Unrest Watched

CRUDE OIL PRICES in the U. S. in late January, 1957, averaged an estimated $3.10 per barrel. That was slightly above the $3.07 average for 1920 and the highest since the $3.75 of 1872—85 years ago. The average price was about $2.79 in 1956 and $2.77 in 1955.

The current price reflects the fact that it takes two present dollars to buy what one prewar dollar would buy. It also reflects heavy postwar increases in costs of finding and producing oil.

The current prices were established through industry-wide revisions in the first half of January, 1957, averaging about 31 cents a barrel. During 1956 there was no general price revision, although changes were made in several areas.

Pennsylvania grade was raised five times in 1956 and once more January 16, 1957, for a total advance of $1.03. California crudes were raised November 21, 1956, and again January 17, 1957, by a total of about 40 cents a barrel. In July and August, 1956, crude prices were cut 7 cents a barrel in some fields of West Central Texas and Oklahoma.

The crude price increases of late 1956 and early 1957 followed tightening of supplies of crude in the world markets after the Suez Canal was blocked and pipe lines from Iraq to the Mediterranean were blown up.

There was considerable uncertainty whether the crude prices established in January, 1957, would continue in effect after resumption of normal movement of Middle East oils to market. Such movement was expected by late spring or early summer. # #

U. S. Average Prices of Crude Oil at Wells
Source: Bureau of Mines except 1957 est.

YEAR	($ Per Bbl.)	YEAR	($ Per Bbl.)	YEAR	($ Per Bbl.)
1918	1.98	1931	.65	1944	1.21
1919	2.01	1932	.87	1945	1.22
1920	3.07	1933	.67		
		1934	1.00	1946	1.41
1921	1.73	1935	.97	1947	1.93
1922	1.61			1948	2.60
1923	1.34	1936	1.09	1949	2.54
1924	1.43	1937	1.18	1950	2.51
1925	1.68	1938	1.13		
		1939	1.02	1951	2.53
1926	1.88	1940	1.02	1952	2.53
1927	1.30			1953	2.68
1928	1.17	1941	1.14	1954	2.78
1929	1.27	1942	1.19	1955	2.77
1930	1.19	1943	1.20		
				1956	2.79
				1957 Jan.	3.10

Crude Price Changes in Mid-Continent, California, and West Texas, by Years
(Dollars Per Barrel)

DATE	Okla., Kans. 36-36.9° Gravity	Calif., Long Beach 27-27.9°	West Texas Sour 30-30.9°
1937: Prior to Jan. 1	$1.10	$1.10	$0.78
January 28	1.22	....	0.88
1938: October 13	1.02	....	0.75
1939: No Changes	....	....	....
1940: February 1	....	1.03	....
1941: March 29	....	....	0.82
April 1	1.07	....	....
April 24	....	1.09	....
May 20	1.17	....	....
May 21	....	....	0.92
May 23	....	1.15	....
1942: Feb. 3; frozen at Oct. 1, 1941 level	1.17	1.15	0.92
1943 1944; 1945: No Changes; prices frozen	....	....	....
1946: April 1: OPA Raise	1.27	1.25	1.02
July 25: Oil Prices decontrolled	1.62	....	1.37
August 1	....	1.50	....
November 15	1.62	....	1.37
November 19	....	....	1.62
1947: March 10	1.67	....	....
March 19	....	1.75	....
July 1	....	1.95	....
October 15	2.07	....	1.82
October 16	....	....	2.32
December 6	2.57	....	....
December 27	....	2.45	....
1948: No Change	....	....	....
1949: June 1	....	2.37	....
1950: December 12	....	2.41	....
1951: Frozen at Jan. 25 level	2.57	2.41	2.32
1952: No Changes; frozen	....	....	....
1953: Feb. 16: decontrolled	....	2.76	....
June 15	2.82	....	2.57
1954: No Change	....	....	....
1955: No Change	....	....	....
1956: November 21	....	2.92	....
1957: January 3	3.07	....	2.82
January 17	....	3.17	....

Changes in Prices of Bradford, Pennsylvania, Crude, by Years
(Dollars Per Barrel)

Date	Price	Date	Price	Date	Price
1937:		1942:		1950:	
Before Jan. 1	$2.15	[1]Feb. 3	$2.75	May 1	$3.65
Feb. 24	2.67	[2]Mar. 20	3.00	June 21	3.75
June 7	2.52			July 19	3.89
Sept. 1	2.00	[3]1943:		Aug. 25	4.00
Oct. 12	2.35			Oct. 9	4.10
Dec. 1	2.20	[3]1944:		Dec. 9	4.25
1938:		[3]1945:		[6]1951:	
Mar. 7	2.05				
June 13	1.80	1946:		[6]1952:	
Sept. 1	1.68	[4]April 1	2.10		
		[5]Aug. 1	2.35	1953:	
1939:		Sept. 1	2.41	Feb. 16	4.40
Jan. 21	1.80	Dec. 9	2.55	Aug. 1	4.55
Feb. 1	1.88			Sept. 21	4.05
Mar. 6	2.00	1947:			
Oct. 6	2.25	Jan. 1	2.65	1954:	
Nov. 1	2.40	Mar. 1	2.81	Jan. 1	3.76
Dec. 1	2.50	April 1	3.91	May 20	3.26
		May 16	4.05	Sept. 1	3.22
1940:		July 1	4.30	Dec. 1	3.35
Jan 1	2.75	Sept. 1	4.50		
May 22	2.50	Dec. 1	5.00	1955:	
June 18	2.25			Jan. 21	3.50
July 12	2.00	1948:		July 11	3.60
Aug. 13	1.85	Dec. 11	4.50	Nov. 1	3.75
Nov. 12	2.00			Dec. 1	3.85
Dec. 17	2.15	1949:			
		Jan. 21	4.00	1956:	
1941:		Mar. 11	3.75	Feb. 6	4.00
Jan. 27	2.30	April 1	3.55	Mar. 16	4.20
April 23	2.40	April 13	3.40	May 16	4.45
May 20	2.55	May 11	3.27	July 16	4.57
June 18	2.75	June 16	3.54	Aug. 16	4.68
Aug. 14	2.98	Dec. 12	3.40		
Aug. 23	2.75		3.54	1957:	
				Jan. 16	4.88

[1] Frozen at Oct. 1, 1941 level. [2] Penn. grade raise granted. [3] No change; price frozen. [4] Raise granted by OPA. [5] Oil prices decontrolled July 25, 1946. [6] No change; price frozen at Jan. 25, 1951, level.

Lubrication Scheduling Cuts Costs

Here's a lube program that will trim down-time, labor and materials and increase plant profit.

C. R. Nelson
Phillips Chemical Company
Bartlesville, Oklahoma

DOES A PLANT NEED A planned schedule of equipment lubrication? Does a plant need at least one person or group who will always be responsible that a piece of equipment will not fail for lack of proper lubrication? Would breakage and operational shutdown of a plant's equipment affect a plant as seriously as failure of an individual's personal car? If the answer is yes to the last question, then it must be yes to the first two.

The question rightly follows: How does the dependability and freedom from repair of a car tie in with a lubrication program for plant equipment?

The answer to the above question and the theme of this article struck home when the family car was in the service station last week for its monthly or 1000 mile chassis lubrication. There it was and all so simple—an automobile with a value when new of not over three thousand dollars—receiving the benefits of a scheduled and responsible lubrication program. The car was receiving the proper lubricants, correctly applied, at the intervals recommended by the vehicle manufacturer.

As demonstrated in an ordinary service station, you will find all of the essentials of a workable plant lubrication program. Bear in mind these essentials,

1. The person responsible,
2. The selection of the proper lubricants and
3. The lubrication record.

The Responsibility of Lubrication—Just as an individual car owner would shy away from trusting the lubrication of his car to an untrained or irresponsible "hand" at a service station, so should a plant insist that trained and responsible people be used to lubricate its plant equipment. The equipment of a modern plant is expensive and complex, shaft speeds and temperatures are high and proper lubrication is more critical than ever before. As the caliber of our equipment goes up, the caliber of the operator or maintenance man must also go up. The first line of defense against equipment breakdown is the person doing the lubricating; select a person who can match the equipment.

Wherever possible it is desirable to have a minimum number of persons responsible for and performing equipment lubrication. This has a two-fold benefit:

1. It encourages the development of skill and know-how in learning the lubrication points and requirements of the equipment.

2. Knowing his responsibility is not shared among many, an oiler will do a more careful and thorough job.

As in any endeavor, workmanship and responsibility that a person can claim as his own will be done better. One of the best investments management can make at the outset of a lubrication program is to upgrade the job of the oiler to one of respect and trust. While a good lubrication man need not be a topnotch mechanic or operator he should have a good mechanical aptitude plus a knowledge of equipment operation. To make an untrained and uninterested man responsible for the assignment can be a costly mistake.

Selection of Lubricants—The proper selection of lubricants requires an interested and reliable source of advice. One of the most willing and acurate sources of such advice is a plant's oil and grease supplier. Through the lubricant supplier, sound judgment and many years of experience can be readily available.

In general, six points should be shown on a lubrication survey.

- Equipment item, number and location.
- Type of equipment (motor, pump, compressor, etc.).
- Location of lubrication points.

The Lubrication Record Contains:

- **Equipment item number**
- **A list of the lubrication points followed by the type of lubricant required**
- **A frequency schedule (daily, weekly, monthly, etc.) for each lubrication point**
- **A lubricant change-out schedule if applicable**
- **A check square after the above points for initial of oiler and date of lubrication work**

• Brand and grade or code designation of lubricant indexed with the location of each lubrication point.

• Recommended frequency of lubrication.

• Recommended frequency of lubricant change-out.

Experience has shown that nearly all of above points can be handled very well by the maintenance or area engineer. The assistance of the oil supplier supplemented by recommendations of the equipment supplier will assist on the last three points.

Much is said these days on the subject of lubricant simplification and reduction in the variety of lubricants required for a given plant. Sizeable savings resulting from a simplification program can be effected in purchasing, warehousing and application. A trained lubricating engineer, either one from the plant who might be thoroughly familiar with the characteristics of the lubricants being used or one from the oil supplier, can assist in such a program. The results can be surprising.

It might be found that one multipurpose grease can do equally well all of the jobs presently requiring several or more types of single purpose greases. Similarly, a general purpose cutting oil might be capable of the majority of machining operations. A multi-grade SAE 10W-30 detergent type motor oil might satisfy the majority of the automotive vehicle engines, or perhaps the bulk priced detergent oil used in the plant's large stationary internal combustion engines will also be suitable for much of the mobile equipment and vehicle engines.

The first money saving benefit from simplification will be found by the Purchasing Department. They may find that "drum lot" lubricant orders will save 25 percent or more over "case lot" orders. They may then find that tank car lots of a single lubricant will save that much again over "drum" orders of several different lubricants. Warehousing will be simplified. The plant will realize a second saving in the way of handling costs. In general, drum handling is time consuming compared to handling from storage tanks through distributing lines, but even drum handling can beat opening "case lots" one container at a time. In short, the advice to larger plants is to take a hard look at the savings which will result from carload lubricant orders. Considering the added savings in purchasing and handling, the pay out rates of bulk storage can be very attractive.

Trial and Risk—Anytime a plant undertakes a program to reduce the variety of required lubricants a certain amount of trial and risk may be involved. At the same time, however, is not this true for the beginning of any profitable plant operation? As an example, here's what is being done at a new Phillips Chemical Company plant near Houston.

To have followed all of the equipment manufacturer's lubricant recommendations explicitly would require the purchasing, warehousing and application difficulties of at least five grades of grease and some thirty types and grades of oil. With the possible exception of electric motors, it was felt that one grease, an NLGI Grade II lithium base multi-purpose grease would posibly do the entire job. The plant oiler would have one grease gun, one grease, and one type of grease fitting. Proportionate reductions have been made in the variety of oils to be used. The total of some 30 different oils were divided into four categories, these being white U.S.P. grade mineral oils, straight mineral oils, compounded gear oils, and extreme pressure gear oils, (while giving and taking on viscosity to gain simplification, considerable care was taken to use the type of oil needed for the specific application involved). The next step was to select the grade or grades of oil having predominate usage in each category. As a final step, wherever practical the oil grade required by the minority of equipment was changed to fit into the majority requirements.

It is entirely possible that experience might show oversimplification and some possible sacrifice in the performance of a few pieces of equipment. However, one reason this path was taken is that experience has also shown it is usually much easier to add a required lubricant, as might be needed later on, than to take one away once it is established. It seems to be a natural tendency to resist changing that which has become custom and has been satisfactory, particularly if it is a matter of altering in any way the lubrication of smoothly running equipment.

The Lubrication Record and Schedule—The lubrication record of a piece of equipment is like the third and balancing leg of a stool, the first two legs being the personnel to handle the lubrication program and the economical selection of lubricants. Without the third support of a lubrication record and schedule the most carefully planned lubrication program will surely collapse.

A scheduling program and lubrication record need not be complex or time consuming to maintain. In fact, simplicity generally adds to effectiveness. Going back to the method used so conveniently by the service station, the record consisted of a tab posted on the door jam showing the mileage opposite the lubrication work performed. Some service stations even use a simple and a very effective reminder system which serves to coordinate their "lube manpower" and "equipment release." The station keeps the mileage and date of last lubrication on their own lube record for each customer's car. They then notify customers several days in advance of the approximate time the car is again due for lubrication. A similar system can be used by your plant oiler, since the only difference is that equipment operating time is logged by hours, days or weeks rather than miles.

The lubrication record and schedule can either be attached to the equipment it describes or kept on a master sheet in the operating control room having jurisdiction over that equipment. In larger plants the first practice is generally preferred, particularly where the oiler might have a substantial area of equipment to cover. Whether attached to the equipment or kept in the control room, up-to-date maintenance of the lube record must be the responsibility of the person doing the lubricating.

Special Lubricant Application—In many plants there will arise special problems where conventional types of lubricants must give way to the new family of synthetics. While there have been occasions to use several types of synthetics in our plants, they are always initially used with a certain degree of caution.

One reason for this caution is that where equipment operating tempera-

tures are within the workable range for mineral oils there has been no indication that the synthetic oils give better lubrication. Also, in cases where the lubricant comes in contact with the process liquid, the chemical composition of the synthetic and its effect on the process must be carefully evaluated. Added to the above is the fact that the prices of synthetic oils are often much higher than those of mineral oils. Accordingly, the use of synthetic oils has been limited to a few applications where superior fire resistance or some other property peculiar to a synthetic oil is required.

The search for a synthetic is not always an easy and well-trod path. Much of the work must be pioneered since it is unlikely for another user to be operating under similar conditions. In spite of all the above obstacles, if your problem is severe, the search for a synthetic can be rewarding.

To cite an example:

Maintenance forces at one of our plants were having trouble coping with excessive carbon deposits in the power end of six Ingersoll-Rand XRD compressors. On the power end these compressors are not unlike steam engines except that in place of steam they use very high temperature nitrous oxide gas. Troublesome carbon deposits fouled the rings, pistons, valves and packing, the excessive rate of the formation requiring shutdown and overhaul of each unit at about three week intervals. A synthetic oil was tried and found very successful in the piston and valve section. The packing has regained a normal life by use of a silicone grease. These synthetics have reduced troublesome deposits in the power end of these compressors to the extent that the frequency of shutdowns for clean-up has been reduced from three weeks to six months or longer.

Using another example:

For some time we have been concerned about the explosion hazards which can exist in plant air systems. While air compressor and air receiver tank explosions are not frequent, they do exist as a potential plant hazard. Based on the theory that such explosions originate from the spontaneous combustion of carbonaceous deposits in rings, valves, piping, etc., several of our plants are currently running field trials of various synthetic oils which are claimed to leave a minimum of deposit. Soap and water emulsions, heretofore used, have eliminated the hazard angle, but lubricating value of the soap solution has not been equal to mineral oil. In addition, deposits from the soap solutions have been expensive from a maintenance standpoint. As a step toward elimination of the above deposits and associated maintenance costs, field trials of various synthetic oils are now in progress in our plant air compressors. Results to date have been encouraging, although in one case a serious question has been raised as to the compatability of the synthetic oil with a critical phase of the plant process using such air.

About the Author

CHARLES R. NELSON is equipment engineer for Phillips Chemical Co., in Bartlesville, Okla. In his present position he evaluates equipment and makes recommendations on maintenance and lubrication. He has held positions as maintenance engineer, maintenance supervisor, maintenance planner, lubrication engineer, and equipment engineer during the past nine years with Phillips Petroleum and Chemical companies. Nelson received a B.S. degree in mechanical engineering in 1947 from the University of Kansas.

It is hoped that the above trials will furnish the answer, an oil of good lubricating value, compatible with plant processes, which will leave a minimum of non-hazardous deposits. The cost of the synthetic will be higher than mineral oil or soap in purchase price. But that extra cost might be returned many times in reduced maintenance costs and safer plant operation.

Lubricating Equipment—It is generally agreed that an oiler's job must be streamlined and simplified as much as possible in terms of lubricant tools and procedure if the maximum amount of equipment is to be properly protected. An oiler should be educated and encouraged to be on the alert for improvements in application techniques. While each plant must necessarily develop those time saving ideas that best suit its particular equipment, here are a few ideas which have worked successfully in some of Phillips plants and can be applied generally to most plant equipment.

- Standardize on grease fittings, with a goal of one size and type of fitting for all equipment.
- In some instances care must be taken to insure that a "general duty" grease does not get into equipment requiring a special grease (such as electric motors, etc.). Consider special fittings for these points and keep a grease gun filled with the special grease to match these fittings only.
- Wherever possible replace metal cup type oilers with bottle type oilers. The bottle type oilers allow a more rapid and accurate check of oil supply.
- Where grease fittings or oil fill points are in hazardous or inaccessible locations, extend tubing or pipe lubricator lines from these points.
- Consider use of a small pull type lube cart by your oiler. This cart should be equipped with the necessary lubricants and equipment to enable the oiler to most easily complete his lubrication rounds.
- Be on the look-out for money making applications of centralized lubrication systems.

The desirable combination of a well chosen oiler and an attentive ear on your part to his suggestions along the above lines cannot be overemphasized.

Selling the Lubrication Plan—It appears reasonable and expected that a better lube program will trim downtime, labor and materials and increase plant profits. With the assistance of the oil supplier an immediate savings can undoubtedly be effected by a competent survey and simplification of lubricants. This can be done without cost and with a minimum of effort. Then emphasize that these savings, however large, in more simple purchasing, storage and handling of the plant's lubricants, are minor compared to the total savings which can be gained from a planned and scheduled lubrication program. One suggested approach to sell the need for a responsible and effective lubrication program may sound like a tedious "pick and shovel" job. At the same time it is a positive approach and can leave little room for doubt. From a careful analysis of a plant's mechanical failures for a given period, total the over-all price of lubrication failure in equipment downtime, product loss, maintenance labor, and materials. This total is the price of not having a planned program for lubrication. Better lubrication is the "best buy" of any preventive maintenance program. ##

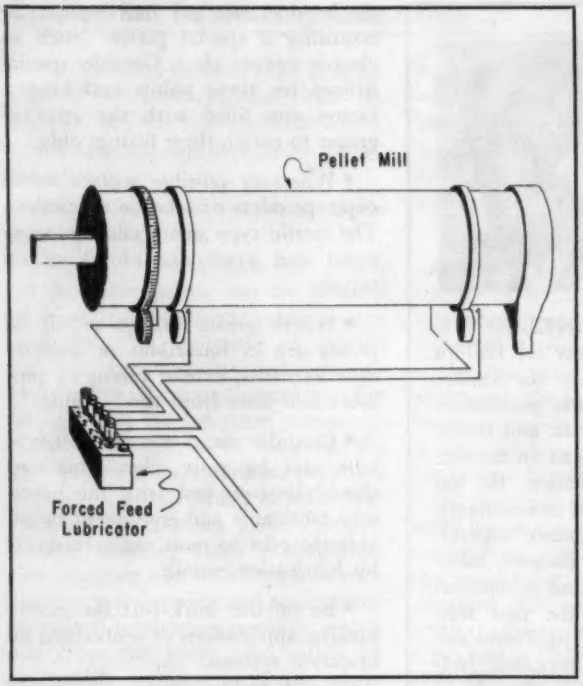

FIGURE 1—Central lubricator serves up to 14 lubricating points.

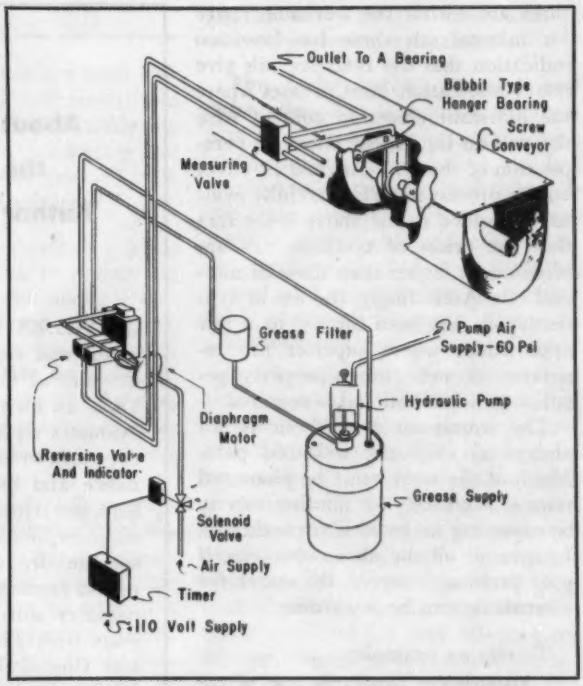

FIGURE 2—An air operated pump automatically lubricates conveyor bearings.

Save With This Automatic Lube System

By using this system you can increase equipment service factors by more than 50 percent and thus spend less maintenance dollars on repairs.

C. W. Gerdes
Phillips Chemical Company
Bartlesville, Okla.

EQUIPMENT DOWNTIME as a result of premature failures not only requires excessive and costly maintenance but also results in a high rate of production loss. These premature failures were in many instances directly caused by improper lubrication. Through the application of automatic forced feed lubrication, equipment service factors have improved and operating and maintenance costs have been decidedly reduced.

Equipment whose continual service is of such a critical nature that its failure creates a plant shutdown was the first to be provided with automatic lubrication. Upon completion of the overall program at Phillips Chemical Company's Philblack plant near Borger, Texas, more than 4100 points requiring lubrication will be provided with proper and complete automatic service.

Past Procedures and Inadequacies—Among process equipment common in the manufacture of carbon black are cylindrical vessels approximately 8 feet in diameter and 48 feet long that pelletize the loose carbon black into the finished product. These pellet mills are girthed with steel tires and rotate on steel trunnions; movement is accomplished through a pinion gear which drives a mating girth gear which also encircles the mill's shell.

The steel tires and trunnions on which each pellet mill rides have metal to metal contact and were previously lubricated by means of a gravity feed oil reservoir mounted at each trunnion. In order to insure proper lubrication at all times the oil level in each reservoir had to be continually maintained and the rate of flow of the lubricant had to be regulated. Oil consumption within this system was at times high whereas the lubricating effectiveness was low,

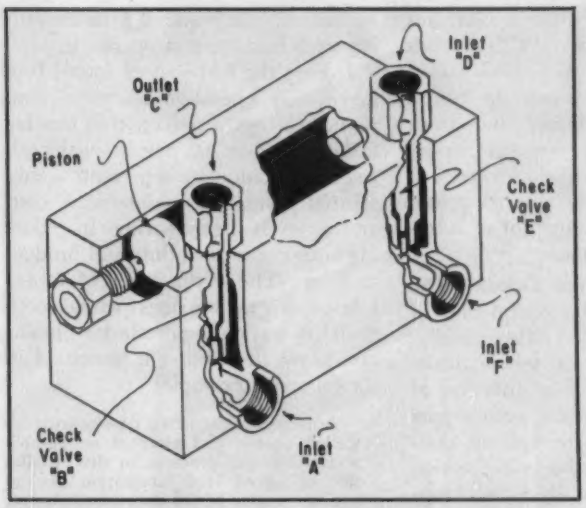

FIGURE 3—A measuring valve supplies the correct amount of lubricant to the system.

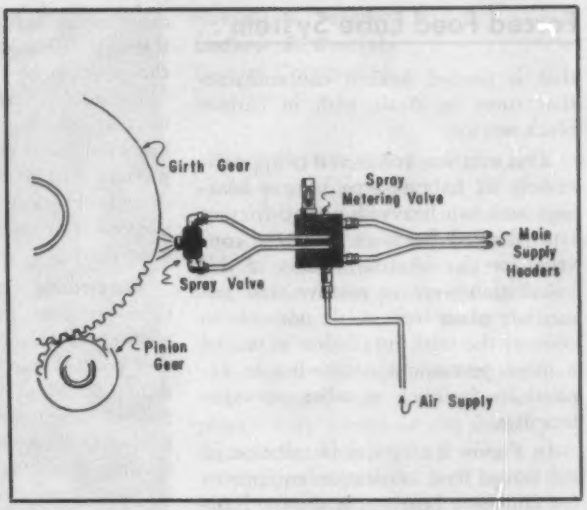

FIGURE 4—Grease is supplied to these bearings in the form of a spray mist.

which was caused by improper regulation of the rate of flow to the trunnions. Trunnion and tire failures were not uncommon and in each case of failure a production loss was realized as well as an extremely high rate of maintenance repair costs.

Pellet mill girth and pinion gear drives have in most instances been lubricated through the manual administration of heavy bodied grease upon the meshing surfaces of the gears. Although quite effective, this method of applying lubricant is not the most efficient. Not only do the hazards of the actual application exist, but sloppiness prevails as the moving gears tend to fling the grease from their surfaces.

Lubrication for babbitt type bearings in screw conveyors in the past has been accomplished through the use of drip type oil cups. These cups were individually mounted on each bearing and contained a reservoir of oil which would last approximately ten days. In carbon black service the inner passages through which the oil flows become obstructed in a relatively short time. When this occurs immediate steps must be taken to either clear the obstruction or replace the oiler as the bearing life will be very short without lubrication. As was the case in many instances, a faulty oil drip cup was not observed in time to prevent the bearing failures and extensive repairs were required to make the equipment serviceable.

Lubrication for anti-friction type bearings has been and in part still is accomplished through the use of manually and pneumatically operated grease guns. Lubrication of the majority of bearings in this category is handled from a routine schedule whose time cycle is of a two week duration. In those cases where lubrication of bearings is more critical, additional provisions must be made to insure proper operation of the equipment that is involved.

Forced Feed Lubrication Equipment—Plant maintenance personnel who were thoroughly familiar with the over-all problem were assigned the task of developing a program which could be completely adapted to all of the equipment. After reviewing the different types of lubricating service that were accomplished manually it was possible to classify the requirements for a complete automatic lubrication program in three different groups.

1. Forced feed oil lubrication for pellet mill steel tires and trunnions.
2. Forced feed grease lubrication for babbitt and anti-friction bearings.
3. Spray lubrication for pellet mill girth and pinion gear drives.

Each installation was developed separately with primary concern being given to equipment whose continual service was most critical and whose maintenance requirements were highest. All equipment failures due to improper lubrication were thoroughly investigated concerning the type and frequency of the failure. The prevailing failure, for instance, of antifriction type bearings in screw conveyors was found to be caused by contamination of the bearing races with carbon black. Lubrication methods at that time were not adequate in providing the flushing action which is required to protect the bearings against contaminants that must be dealt with in carbon black service.

Experiments were first conducted with forced feed lubrication for the pellet mill steel tires and trunnions. Initial results proved so conclusive that plans were made to install a sufficient number of lubricators to service the trunnions on all of the pellet mills. Forced feed lubricators having up to a maximum of fourteen points were centrally located and each lubricating point was tied to a pellet mill trunnion. Figure 1 shows a typical installation of this type of lubricating medium. The service life of the steel tires and trunnions was increased approximately 50 percent and oil consumption was decreased by a greater percentage through the installation of this equipment. Each lubricator has its own reservoir of oil which was sized to require infrequent re-filling.

Babbitt and Anti-Friction Type Bearings—Further experiments conducted with forced feed lubrication was centered about supplying service to babbitt and anti-friction type bearings in conveying equipment. After reviewing available lubrication systems by various manufacturers of forced feed lubricating equipment using grease as the lubricant, an experimental installation was made with a system having a sufficient operating pressure to provide the flushing action required in providing the protection

that is needed against contaminants that must be dealt with in carbon black service.

This unit was connected to approximately 52 babbitt type hanger bearings and two heavy duty anti-friction type flanged bearings in screw conveyor service. Actual results of this installation were so positive that immediate plans were made not only to convert the trial installation to one of a more permanent nature but to expand its facilities to other conveyor bearings.

In Figure 2 a typical installation of the forced feed lubrication equipment for conveyor bearings is shown. Basically, its principle of operation is as follows: An air operated pump having a pressure ratio of 40 to 1 is mounted directly on the drum of lubricant. Operating on a supply pressure of 60 pounds per square inch the pump delivers lubricant through the two main supply headers at a pressure of 2400 pounds per square inch. The lubricant is maintained under pressure at all times and alternately flows through each header; the direction of which is controlled by a reversing valve. The operation of the reversing valve is entirely automatic and directs the flow of lubricant into one main header until it is up to operating pressure while simultaneously relieving the pressure from the other main header. To complete the cycle of operation, flow is then reversed and directed through the other main header.

A measured amount of lubricant is supplied to one-half of the bearings in the system through each of the main supply headers and in turn is controlled by a proportioning valve for each bearing. A cut away view of the measuring valve is shown in Figure 3. Pressure from one main supply header, forces lubricant into the valve through inlet "A," opens the admitting side of the check valve "B" and closes the outlet side to passage "C." Continued pressure forces lubricant to flow into the cylinder and move the piston through its full stroke which causes the lubricant ahead of the piston to flow through the outlet port "D." Pressure in this direction applies a reversing action on the check valve "E" which opens the outlet port "D" and closes the inlet side "F." Pressure when supplied from the other main header forces lubricant through the inlet port "F," reverses the position of the two check valves "B" and "E" and causes the piston to traverse the cylinder and force lubricant to flow through the outlet passage "C." Each outlet port is directly connected to a bearing and delivers a measured amount of lubricant through each cycle.

Automatic Control Circuit—The time required in the completion of each cycle is controlled automatically; the control circuit is schematically shown in Figure 2. The direction of flow of lubricant to each main supply header is controlled through the positioning of the reversing valve which in turn is controlled by a timer operated three-way solenoid valve that alternately supplies and vents air pressure to the diaphragm top works mounted directly on the reversing valve. The total time requirements for a complete cycle is governed by the total number of bearings serviced by the system and can be varied in accordance with pre-determined rates of lubrication. The total number of bearings which can be lubricated through one installation is limited only by practical piping installations and the maintaining of the prescribed frequency of lubrication. The pump must have time to deliver enough lubricant through each main header to build up the required pressure during each half cycle of operation.

During the first year of forced feed lubrication operation to screw conveyor bearings, a reduction in bearing failures of over 60 percent was realized. This reduction represents a substantial savings in maintenance costs and an even higher savings in reducing equipment downtime and production loss. The effectiveness of forced lubrication to bearings whose continual operation is necessary to maintain plant production is presented in the following example:

> A flanged anti-friction type bearing installed on the end plate of an 18-inch screw conveyor previous to the installation of forced feed lubrication had an average service life of approximately two months. The type of service this bearing must withstand is so severe that unless proper lubrication can be maintained carbon black will penetrate the bearing races and accelerate its failure. Since forced feed lubrication has been provided for this bearing not one failure was experienced in over one year's continual service. Periodic inspections were made and its condition was observed to be equivalent to that of a new bearing.

Currently under development is a forced feed lubricator which will supply grease as a lubricant in the form of a spray mist directly on the meshing surfaces of a pellet mill girth and pinion gear drive. This equipment was installed as an integral part of the automatic lubrication system for screw conveyor bearings. It operates from the same pressure and time cycle as this system to create the atomization required in spraying the lubricant on the open gears.

In Figure 4, a typical installation is schematically shown. Lubricant from the main supply headers is piped directly to the spray metering valve which delivers the proper amount of lubricant to the spray nozzle through an air admitting valve. The air admitting valve is actuated by the pressure developed on the lubricant by the hydraulic pump. Each time a metered amount of lubricant is discharged under pressure by the measuring valve, the air valve piston is unseated allowing air and lubricant to flow to the spray nozzle. The flow of lubricant is cut off within the spray valve when the valve piston reaches the end of its travel. When in this position the air valve reseats, automatically shutting off the air supply. This equipment places the proper amount of lubricant on the gear surfaces in the intervals desired and the entire operation is automatic. ##

About the Author

C. W. GERDES is maintenance planning supervisor for Phillips Chemical Co. Philblack plant at Borger, Texas. He plans and coordinates all maintenance repair and construction work, supervises the Planning section and determines job procedures and methods. He graduated from Montana State College in June 1950 with a B.S. degree in mechanical engineering, then joined Phillips Chemical where he has held his present position for the past three years.

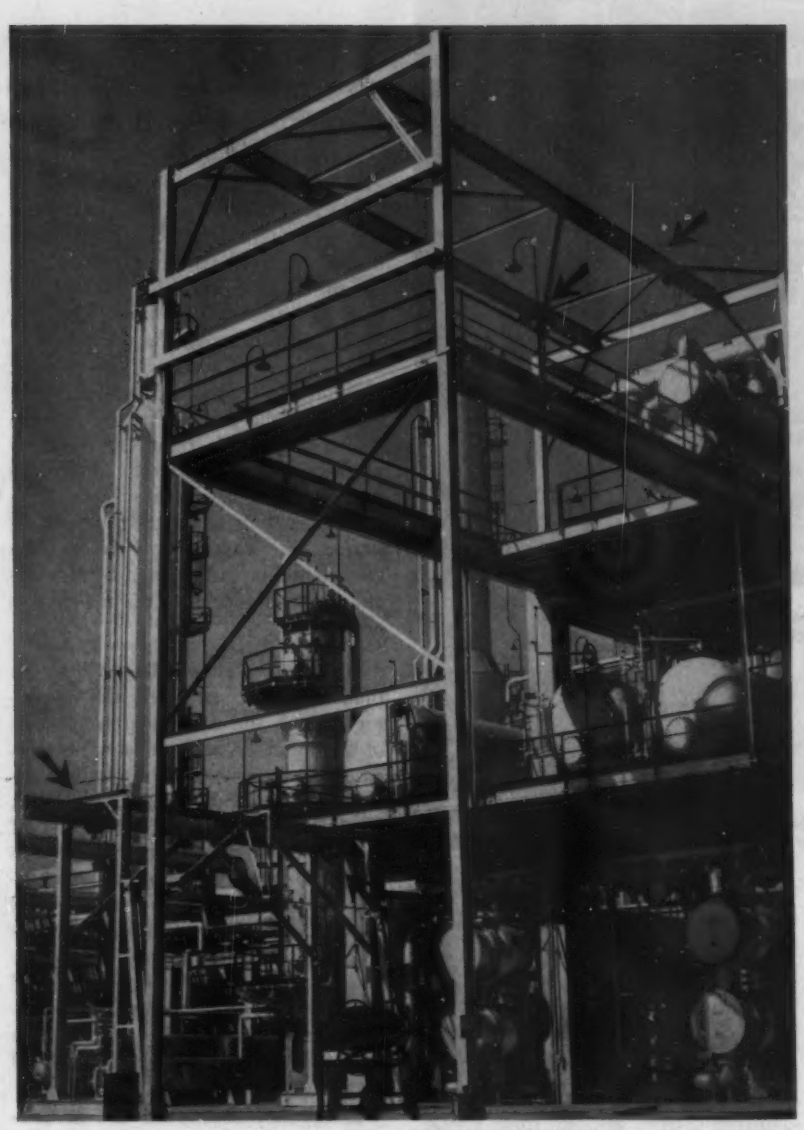

FIGURE 1—Overhead, monorail cranes provide a convenient means of handling heat exchanger bundles during inspection and cleanout operations.

Design Your Plants For Low Maintenance

To assure optimum maintenance results at the lowest cost, you must start at the plant's roots—the initial design stage.

Russell G. Johnson and
Ludlow S. Daniels
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THE PURPOSE of maintenance is to keep process plants in profitable operation. Success is measured in terms of over-all plant economics—profits are made only when plants run, while nothing but expense is incurred when they are down for repairs.

To assure the optimum in maintenance results, one must start at the plant's very roots—at the initial design stage. Every factor which can assure good operation and meet the low maintenance requirement must be designed into the process plant at this time.

This maintenance story is not especially directed to maintenance men, but rather to the managements and engineering staffs who specify the process plants for design and construction by the engineer-builder. These groups control the initial installation choices, and thereby set the final maintenance requirements for their plants.

The designers of process plants and service facilities solve many potential maintenance problems by engineering them out of their designs. By the wise choice of an alloy, the design of a process or control scheme, the selection of a pump spare or the specification of a fouling factor, as examples, they achieve plants that stay on stream for long periods and suffer few breakdowns in operation.

In the final instance, however well planned, all plants must be inspected, cleaned and repaired. Since failures still do occur despite all efforts to avoid them, the designers must also make adequate provision for the service needs that can arise during operation, and for the cleanout and maintenance procedures that must be performed at the end of each operating period. Many of these provisions, inherent in the normal design of a unit, are the usual practice of the industry. Others are developed to meet the specific requirements of the particular plant.

Besides the purely process specifications set up for a new plant, decisions must be made regarding the minimum life for equipment design, the desirable length of operating periods, and the ratio of onstream time to

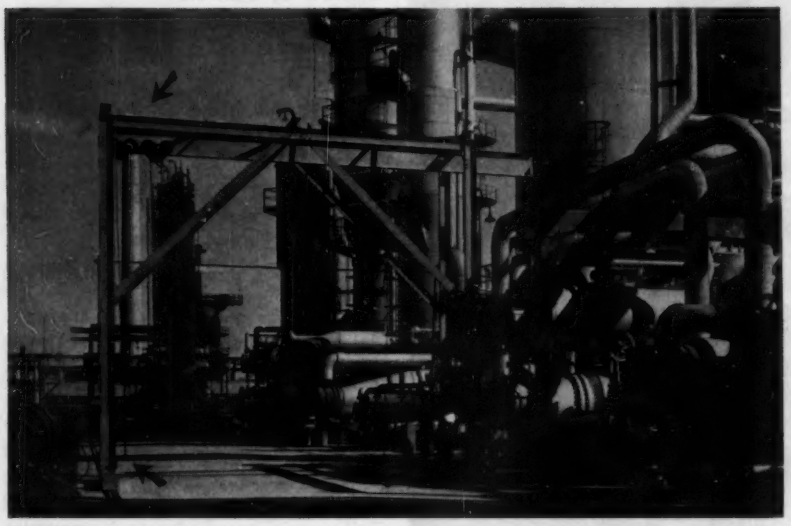

FIGURE 2—Special cranes and support trolleys allow easy transportation for cleaning and inspection.

downtime necessary to meet production requirements.

Plant Life—The probable life span of a process unit or plant can sometimes be estimated by comparison with similar installations. Consideration of the available supplies and reserves of the charge stocks and of probable market demands for the products may allow a reasonable estimate to be made. Economic studies of the plant investments and payout times will show the minimum length of time required to recover costs and will indicate the returns to be gained through continued operation after the payout.

The nominal length of life that is to be used for selecting equipment or determining metal thicknesses is of importance to the designer as it greatly affects the cost of a plant. Equipment and materials must generally be selected that will assure the desired operating results and durability for the minimum number of dollars. If the circumstances under which the designs are made allow credit for improved over-all plant economics the designer often can effect worthwhile savings through modest increases in plant investment.

Plant life requirement may be stated in years. Furnace tubes, for instance, are normally designed for a definite number of operating hours until the calculated time of rupture. More often equipment life requirements are indirectly stated in the form of corrosion allowances thought to be suitable for the various fluids and operating conditions to be encountered in a plant. This is the practical approach, though plant corrosion rates still present the designer with many uncertainties despite the very considerable progress made in recent years.

The life of static equipment such as vessels and piping is directly established by corrosion allowances and rates, erosion effects, and in high temperature operations by the creep rates of metals and the service performance of refractories and insulations.

The life of moving machinery is influenced by mechanical wear, fatigue, the effectiveness of lubrication and other factors. The bulk of maintenance operations for vessels and piping involve cleanout and corrosion less repairs.

Maintenance for pumps and compressors, control valves and other dynamic equipment necessarily involves cleanout work, but consists largely of adjustment and the replacement of worn and broken parts. Thus the potential life of a large compressor is long. The major parts suffer little wear and by replacement of bearing sleeves, valves, pistons, cylinder liners and the like the machines can be kept running many years. The real criterion for this latter class of equipment is that it be able to stay in service without interruption for the full scheduled time of each operating period of the plant. Otherwise spares must be provided if breakdown in service is a likelihood and of serious consequence.

Operating Requirements—Modern oil refinery and petrochemical units are usually of the continuous operation type. The batch processes of earlier days have largely given way to units that stay on stream for months or years at a time. The reasons are economic. Better products are thereby achieved at lower cost. The large volumes of materials processed and the precise control of operating conditions required in these plants are also favorable to continuous operations. Economically it is usually better that the length of operating periods be limited only by process considerations rather than by the mechanical serviceability of the process equipment.

Operation Scheduling—Process plant managers schedule the operating periods and the downtime periods of their units as accurately as possible. They have developed thorough maintenance programs to keep close check of the condition of each item of equipment in their plants, and try to effect all needed repairs and replacements during the times when process factors, feed supply or market factors require the units to come down. They have been markedly successful and have greatly improved plant operating efficiencies in comparison with the earlier practice of "running until something gives."

Emergency shutdowns are hazardous. Even though a failure that causes a shutdown may not be dangerous, it may force hasty decisions by the unit operators and thus lead to costly mistakes. Unplanned stoppages besides being hazardous are extremely costly in terms of lost production. While a scheduled shutdown of a process unit may be coordinated to other plant requirements, the accidental shutdown more often than not will upset or even stop the operation of other related process units. Commitments for receiving feed stocks and delivering products add further to the problems and embarrassments that attend any extended interruption in the normal plant schedules. Thus the absolute necessity for reliability in process plants is clear enough. It is a factor that must be given full consideration in design work along with the more

easily evaluated questions of process yields and product qualities.

Standby Equipment—The extent of the spares provided in a process plant design is determined by plant first-cost considerations, the required time on stream between shutdowns, the reliability record of similar equipment, the hazards incurred if failure should occur, and other points.

As an example of the typical design problem, the length of the operating period for a catalytic reformer may be limited, say, to ten months, as set by the feasible dimensions of the catalyst beds, the catalyst being very expensive and bed pressure drop a critical design variable. It would then be costly and uneconomical to limit the run to a lesser period by some mechanical factor such as the length of time a pump could be kept in service. A spare pump or pumps would be well worthwhile. Necessary pump maintenance could be performed while the plant continued in operation. Of course, the run length might also be extended by providing for catalyst regeneration during operation, but that would be a separate problem.

Pumps are relatively inexpensive. Compressors are less so, and the provision of standby compressors may be more difficult to justify. However, large compressors are fairly dependable and careful servicing or preventative maintenance is effective in keeping them running for long periods without breakdowns. In some cases a degree of protection against plant shutdown from compressor failures can be had by providing two or more over-size machines for continuous operation at less than full load capacity. Failure of a single machine will still allow plant operation at reduced capacity. At least a shutdown is avoided, though at the cost of additional investment. As an alternate, three half-size machines are sometimes installed. In the first instance the cost of the compressor installation may be increased about 33 percent in the second case, about 50 percent.

This idea has been carried too far in some plants with many small machines in parallel service. The extra machines multiply the breakdowns that occur out of proportion to a process load which might better be handled by fewer but larger machines.

The coking of thermal conversion coils is often the limiting factor that sets the maximum run length in such plants. Through good furnace design and related process measures the operating periods of thermal cracking, delayed coking, thermal reforming, visbreaking and comparable plants may be extended months beyond the earlier day experience with such units. Along with process design improvement, mechanical equipment and design has also been improved so that it does not usually limit the run length. Thus the inevitable maintenance operations of cleanout and repair are pushed back a little farther and the service factors are improved. Thermal conversion units usually run until pressure drop in the coil builds up enough to seriously lower the flow that can be put through by the charge pump. Extra pump head may extend the operating period in some cases. In any event, the high cost of fired heaters per unit of heat transfer usually excludes the provision of standby equipment.

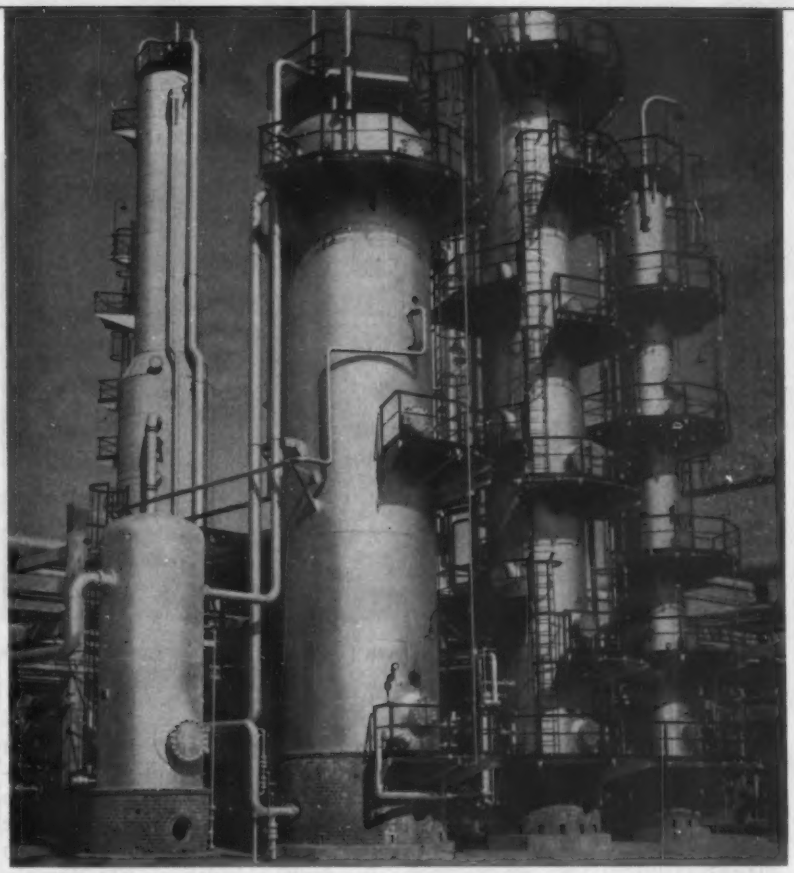

FIGURE 3—Sufficient manholes and access platforms determine the maintenance crew size during plant shutdown.

Some critical pyrolysis heaters, as in ethylene production service, are necessarily built in small capacities, and multiple installation is required to reach the over-all plant capacities desired for typical commercial installations. Such heaters may have an operating period of a month to six weeks. They are individually shut down for decoking as required, with the other heaters remaining in operation to allow over-all plant operating periods of a year or more.

In most plant designs, the heat exchanger and furnace surface is installed to generously meet process requirements without much overcapacity. From the designer's viewpoint, such equipment usually operates at maximum conditions only a few days of each year during extremes of hot or cold weather, so there is considerable "extra" safety factor available most of each year. Heat transfer equipment is expensive, especially when alloys are required to meet corrosion problems, so the practice is usually correct.

Control valve stations commonly are arranged to allow bypass operation in the event of control valve failure. Such bypass and block arrangements add relatively little to plant cost, and do help to avoid emergency shutdowns for control valve repairs.

The design procedure always is one of balance and compromise. The

FIGURE 4—Access ways must be sufficiently open to allow entry and easy use of crane cars or winch trucks for fast repair and replacement after equipment breakdown.

many possible causes of inadvertent shutdowns must be considered and, to the extent feasible, eliminated.

Process Factors—Fractionation equipment in clean and noncorrosive services requires little maintenance beyond routine inspection. Dirty and corrosive stocks and coking or gumming temperature conditions, however, are another matter. The cleaning, inspection and repair of columns and drums in such services may be a considerable part of the maintenance work required during a plant turnaround. The plugging or coking of fractionation trays is a common cause of interruption in plant operations. Many such difficulties may be avoided at the plant design stage. Provision of baffles rather than vapor cap bubble trays in the high temperature zone of a cracking unit fractionator is a typical instance. Heavy coke deposits that would seriously plug bubble cap trays have relatively less effect on properly designed baffles.

Adequate design reflux flow rates in such zones can decrease the formation of dry point coke and provide cleaner distillate streams. The amount of entrained residual oils in distillate recycle streams in thermal conversion processes in turn is all important, "dirty" oil leading to early shutdown from the formation of coke in cracking coils.

Fouling Allowances—The fouling allowances included in the over-all heat transfer rate of an exchanger or cooler are no more or no less than an allowance to assure a desired length of operating period for such equipment before shutdown for cleaning is necessary. The cost of such equipment is greatly affected by the size of the fouling factors selected in the design calculations. For example, a condenser for a stabilizer overhead stream may have an over-all transfer rate of 150 Btu/hr/sq ft/F when clean. A "normal" hydrocarbon side fouling factor of 0.001 plus a "normal" water side fouling factor of an additional 0.001 will reduce the design "dirty" transfer coefficient to about 115 Btu/hr/sq ft/F, an increase in surface area of 30 percent, and a proportionate increase in cost. This is a normal design case. If, however, the cooling water is exceptionally dirty, the necessary fouling allowance for a desired length of operation between cleanouts may be 0.006 which would drop the transfer rate to about 73 Btu/hr/F, more than doubling the required area. Such very dirty cooling water is rare, but in a case that involved a great deal of heat transfer equipment, the designer would do well, perhaps, to investigate the cost of water treatment as an alternate.

Corrosion—The part of corrosion in setting the service life of process plant equipment has been noted earlier.

The designer must choose materials that afford the required protection and yet fit within the other design considerations of a plant. Over-design here is costly. The practical material choice is usually the one that will keep the equipment in service with moderate or low maintenance expense and with little risk of emergency shutdown for repairs.

Carbon steel in various forms is the universal construction material for process plants. Cast iron is also widely used where it is suitable, because of its relatively low cost. Where operating conditions of temperature and pressure are too severe for these standard materials, or where serious corrosion problems exist, alloy steels and also non-ferrous metals are used. The cost of these more resistant materials is relatively great. Alloy steel with 2 chrome ½ moly composition has a base cost about 125 percent greater than carbon steel, while 12 chrome materials cost almost 800 percent more, and one type of 18 chrome-8 nickel (AISI Type 316), which is especially corrosion resistant in many severe services, costs almost sixteen times as much as carbon steel. Copper, zinc and tin alloys are also relatively expensive. So the designer uses such materials only to the extent necessary, reserving the more expensive ones for the severe conditions where the additional investment will be fully repaid either in operating reliability or in decreased maintenance costs.

Layout—The arrangement of the individual items of equipment in a process unit is important from the standpoint of allowing the easy servicing of such spares as are provided during normal plant operation and also to facilitate the general maintenance operations of cleanout, repair, and adjustment that are carried on during plant shutdowns. Accessibility is the important requirement.

If possible, pumps should be located so that they can be readily approached by a portable crane car or automobile winch truck, to be moved bodily to the plant repair shops when this is desirable. Heat exchange equipment should be located so that bundles can readily be removed for cleaning and repair. Effective means should be designed into the plant to support such bundles as they are being removed from their shells, and jacks or pulling hoists should be arranged to do the actual pulling. Where pressure levels require elevated condenser and exchanger location, suitable handling facilities, walkways and access means must be provided. However, in those cases where process conditions do not require an elevated location, exchange

equipment is best located near grade.

Fired heaters require work during shutdowns. This usually means tube cleaning and the inspection and testing of coils for corrosion and pressure tightness, along with any other incidental furnace repair work that may be indicated. For thermal conversion processes, decoking of furnace tubes must be accommodated. Such fouling or deposits are removed by mechanical means, by chemical cleaning methods or by steam-air decoking. The method for cleaning must be decided at the design stage and the necessary facilities installed.

Vessels, especially fractionators and distillation columns in "dirty" services, must be provided with suitable access, cleaning and handling facilities for trays and internals. Reaction and treating vessels having catalysts or other beds of solids must be arranged to facilitate the dumping of such beds, vessel cleaning as required, and bed replacement.

A sometimes neglected aspect of design for maintenance, for plants that are likely to require extensive cleaning, repair, replacement or recharging during normal shutdowns, is the necessity that a great number of these operations be conducted simultaneously. Downtime must be held to the very minimum possible, so large crews of craftsmen must work closely together. It is easy to get them too close, to the detriment of their efficiency and speed.

Sufficient room must be provided for these crews to work without interferences. Service facilities such as heat exchanger handling equipment, for instance, must be adequate to not only service each unit adequately but also to service it in the available time. A layout that handles one exchanger at a time while preventing or delaying work on other exchangers might well be the cause of excessively long shutdown periods for a plant.

Shop Facilities—While the careful design of process units can decrease the amount of repair and replacement work that will be required, there comes the time when the units must be shut down for servicing. The maintenance shop facilities must then be adequate if the cleanout and repair work is to be completed without delay and the plant returned to operation in good order.

There is an opportunity to keep plant over-all investment low when the location is such that major equipment repairs can be made in nearby outside shops. In remote locations, the process plant must necessarily be independent of almost all outside help. Such plants require and have extensive shop and service facilities, sometimes going so far as to provide for the complete fabrication or remanufacture of vessels, heat exchangers, valves, and the like.

It is fairly easy to underestimate the required maintenance facilities for a new plant. Management understandably wants to keep investments low, and to keep overhead charges down. If this is carried too far however, unexpected costs can far exceed possible savings. For instance, a plant located two hundred miles from large machine shops and plate fabrication plants can make a strong argument for the installation of minimum repair and service facilities. The reasoning is that minor repairs can be handled by a small plant staff and modest maintenance shops and that more extensive work can be sent by motor truck to the not too distant shops. This works fine if not too many troubles develop, but it is also true that some plants have been in difficulties through such planning. The two-way trucking time for a one-day repair job brings the total downtime to three days, with the possibility of three days production lost instead of one.

The shop facilities must provide suitable working areas and the many general use and special purpose tools and machines needed by the variety of craft groups, technicians, specialists, engineers and workmen which make up the modern process plant maintenance force.

Storage facilities must be provided for working tools and machines, both indoors and outside as may be suitable.

Storage arrangements are required for spare equipment items and replacement parts and for bulk construction materials such as pipe, tubing, steel plate and structural shapes, timber and lumber, insulation and refractory materials, and a host of others.

There is a tendency in recent years to group the variety of crafts and maintenance service personnel and their tools and machine facilities into central shops areas. The better arrangements may employ a number of suitable shops buildings grouped together with office and stores warehousing spaces, or may even combine all the maintenance services into one large building specially designed for the purpose. In either case the scattering of maintenance services into inadequate shop facilities at random locations about a large plant, a condition that once was common practice, is now largely avoided. As a result the quality of maintenance work has improved, and maintenance costs have been held to acceptable levels.

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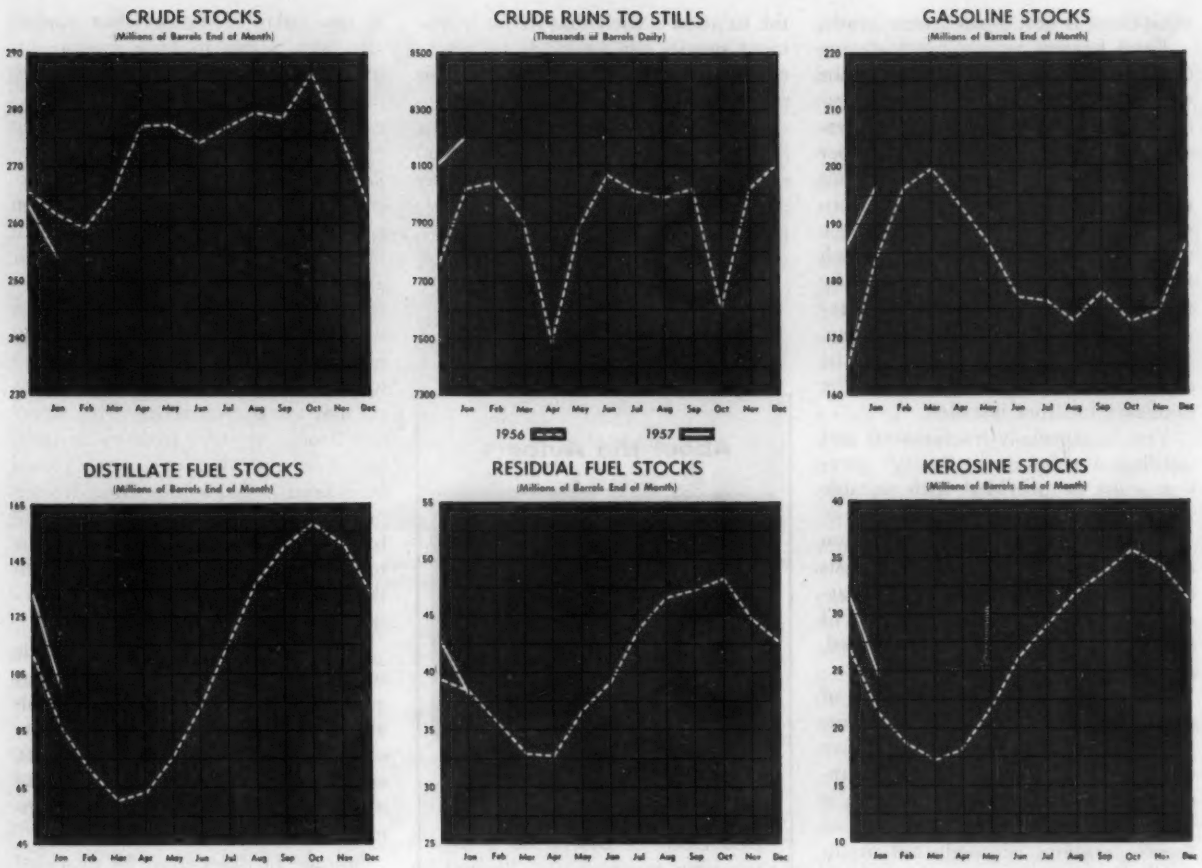

Taking Stock

Cecil W. Smith
Economics Editor

- **Refinery runs reach new peak**
- **Gasoline output decreased, but**
- **Stocks climb to new all-time high**

MONTH	CRUDE OIL			GASOLINE		KEROSINE		DISTILLATE FUEL		RESIDUAL FUEL		DAILY IMPORTS	
	Production Daily	Runs to Stills Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Production Daily	Stocks End of Month	Crude Oil	Total Oils
1955:													
January	6,761	7,379	260,156	3,639	169,562	409	23,266	1,740	86,692	1,235	49,457	739	1,348
February	6,835	7,549	258,630	3,655	181,643	374	18,291	1,847	68,513	1,239	46,042	751	1,379
March	6,886	7,374	264,430	3,543	183,972	357	18,187	1,703	62,457	1,185	44,970	742	1,319
April	6,887	7,136	275,232	3,502	175,601	312	21,486	1,534	70,139	1,110	43,838	697	1,123
May	6,677	7,281	276,948	3,605	168,751	296	26,372	1,519	83,559	1,111	45,083	742	1,137
June	6,613	7,484	270,850	3,725	157,439	269	29,830	1,628	100,652	1,080	44,398	764	1,159
July	6,632	7,580	264,601	3,824	157,079	286	32,749	1,575	119,169	1,091	44,894	860	1,161
August	6,665	7,580	256,427	3,858	151,912	290	35,292	1,621	133,675	1,090	45,480	758	1,155
September	6,731	7,483	256,269	3,784	150,194	279	36,361	1,621	143,248	1,061	46,267	829	1,218
October	6,837	7,465	267,346	3,827	153,103	309	36,705	1,612	152,288	1,123	47,040	821	1,206
November	7,014	7,692	260,707	3,867	157,871	341	33,283	1,680	141,808	1,214	44,071	823	1,322
December	7,155	7,762	265,610	3,916	165,433	395	26,770	1,765	111,333	1,286	39,174	884	1,502
1956:													
January	7,199	8,023	261,592	3,927	183,905	385	21,310	1,923	86,141	1,344	38,247	805	1,422
February	7,208	8,047	259,504	3,854	196,092	385	18,712	1,918	71,335	1,286	35,673	878	1,472
March	7,278	7,914	265,683	3,829	199,698	342	17,215	1,808	60,846	1,213	32,984	934	1,425
April	7,146	7,487	277,121	3,646	193,299	299	18,227	1,713	63,571	1,130	32,740	815	1,305
May	7,064	7,896	277,497	3,859	186,673	292	21,883	1,667	75,928	1,149	36,607	938	1,416
June	7,100	8,071	274,491	3,976	177,076	290	26,111	1,755	93,758	1,098	39,073	987	1,426
July	7,090	8,014	277,008	3,975	176,536	296	28,990	1,767	115,787	1,066	43,958	1,084	1,463
August	7,195	7,995	279,944	4,037	172,939	313	31,826	1,839	137,905	1,091	46,617	1,001	1,399
September	7,054	8,024	278,791	3,991	177,974	329	33,588	1,845	150,411	1,062	47,342	1,043	1,452
October	6,966	7,608	286,560	3,773	172,798	356	35,667	1,772	158,871	1,082	48,400	1,004	1,541
November	7,139	8,031	275,995	3,913	174,808	384	34,329	1,841	151,517	1,182	44,590	871	1,362
December	7,376	8,114	263,027	3,959	186,374	383	31,453	1,990	133,742	1,238	42,696	864	1,453
1957:													
January	7,412	8,205	254,048	3,900	196,351	376	24,622	2,077	100,369	1,270	38,212	796	1,317
Week Ended:													
2-22-57	7,567	7,795	251,684	3,668	204,122	331	21,723	1,980	87,895	1,236	35,772	832	1,437
2-24-56	8,084	8,084	255,466	3,770	193,988	365	22,552	1,976	74,330	1,261	37,102	830	1,398

Source: Data for last two months from API; prior monthly data from Bureau of Mines. Data in thousands of barrels.

Hydrogen Use High for Some Stocks

The nature of the charge stock influences the amount of hydrogen required for treating. These data for Unifining indicate some of the reactions which occur.

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IN UNIFINING various catalytic cycle stocks by processing them under hydrogen pressure over a cobalt-molybdenum type catalyst, large differences in hydrogen consumption have been noted. Analysis of one aromatic cycle oil which consumed an unusually high amount of hydrogen showed that it contained substantial amounts of naphthalenes and sulfur compounds, the latter presumed to be benzothiophenes.

By Unifining at a pressure under 1000 pounds per square inch gage, sulfur compounds were converted to alkyl benzenes, and naphthalenes were reduced to tetralins. Above 1000 psig, saturation of tetralins and alkyl aromatics proceeded. Ring opening was negligible. These reactions were confirmed by studies on pure bicyclic compounds *and explain the high hydrogen consumption observed.*

Temperatures employed in processing light cycle oils are usually between 500 and 800 F. The design pressure will depend on the particular service required, but for purposes of this presentation, pressures up to 1000 psig are referred to as mild conditions; whereas pressures above about 1000 psig are referred to as severe conditions. Previous publications[1,2,3,4,5] include other details of this process.

In our bench scale Unifining studies many catalytic light cycle oils have been processed. Hydrogen consumption for mild Unifining of these cycle oils usually varies between 200 and 400 cubic feet per barrel. However, in one unusual case hydrogen consumption for mild Unifining of a Wyoming light cycle oil was 850 cfb and for severe Unifining was 1430 cfb. Inspection data on two typical raw light cycle oils and on the unusual light cycle oil before and after Unifining are given in Table 1. It may be noted that the unusual light cycle oil, *C*, has a lower API gravity, a much higher sulfur, and a higher aromatic content than do the typical light cycle oils, *A* and *B*.

The greater hydrogen consumption in the case of cycle oil, *C*, was examined more closely. The sample

TABLE 1

Unifining Catalytically Cracked Light Cycle Oils

	A Typical Mid-Continent Light Cycle Oil		B Typical Wyoming Light Cycle Oil		C Unusual Wyoming Light Cycle Oil		
	Before	After	Before	After	Before	Mild	Severe
	Unifining		Unifining		Unifining		
Product Distribution							
H_2S, Weight Percent	.....	.4	.....	1.0	.....	2.1	2.1
C_1-C_4, Hcbns, Weight Percent	.....	.2	.....	.4	.....	.3	.8
C_5 + Liquid, Volume Percent	.....	101.5	.....	100.5	.....	102.1	104.1
°API	27.0	29.3	29.0	32.3	19.3	26.2	29.9
Specific Gravity 60/60	.8927	.8800	.....	.....	.938	.897	.877
100 ml. Distillation							
IBP	427	435	440	416	430	377	368
10 Percent	477	468	468	450	458	413	403
50 Percent	518	511	512	499	483	463	452
90 Percent	585	588	585	578	515	510	504
End Point	621	731	647	645	554	564	560
Molecular Weight	.....	.....	.....	.....	170	165	165
H_2 Consumption CF/B*	.....	408	.....	371	.....	850	1430
Hydrogen Content, Wt. % (Beta-Ray)	11.52	12.07	11.90	12.52	9.86	11.06	11.95
Sulfur, Weight Percent	.39	.03	.93	.038	.198	0.16	.009
Bromine No.	17.5	6.1	9.3	5.1	21.8	8.0	7.7
Aromatics + Olefins, Volume Percent†	50.9	48.7	43.6	41.6	77.0	72.2	57.2
Cetane No.	34.9	37.5	39.0	40.7	<22	<22	26.4
Refractive Index	1.50963	1.49631	.....	.....	1.53914	1.50871	.....
Specific Dispersion	174.6	151.2	.....	.....	182.4	164.9	139.5

* Experimental. † ASTM D 875—46T.

was fractionated into appropriate cuts and analyzed by ultraviolet absorption[6] for naphthalenes. Fluorescent indicator analyses (FIA)[7] were also obtained on the total samples. The following assumptions were made concerning component types:

1. All of the sulfur compounds were benzothiophenic and on Unifining produced alkylbenzenes.
2. There were no long side chains on the aromatic nuclei.
3. Tetralins on the average were dimethyltetralins.
4. Aromatic olefins on the average were vinyl naphthalenes.
5. The paraffins + naphthenes on the average were $C_{14}H_{29}$.

This is the process used . . .

Unifining is a hydrogenation process carried out at elevated temperatures and pressures over a specially prepared cobalt and molybdenum type catalyst. It is licensed by Universal Oil Products Company and by Union Oil Company of California. The object of Unifining is to remove impurities and thereby upgrade fuels; that is, sulfur, nitrogen, oxygen and metals are removed and olefins are saturated. In this way gum forming materials are minimized. The Unifining process is capable of improving a wide variety of petroleum charge stocks, both straight run and cracked, such as naphthas, kerosines, middle distillates, atmospheric gas oils, and heavy vacuum gas oils. However, this paper is limited to a discussion of processing catalytically cracked light cycle oils and selected pure components.

On the basis of the above analyses and assumptions nine compounds and component types were distinguished; empirical formulas, weight percent hydrogen, and method of determination of these are listed in Table 2. Components were chosen which would boil in the range of cycle oil, *C*. On the basis of these analyses calculations of components and component types in cycle oil, *C*, before and after Unifining were made and are given in Table 3. It may be noted that the primary components in cycle oil, *C*, are "dimethyl"tetralins, paraffins + naphthenes, dimethylnaphthalenes, and methylbenzothiophene. Under mild Unifining conditions methylbenzothiophene disappears, there is a substantial reduction in all of the naphthalenes and an increase in "dimethyl"tetralin, alkylbenzenes, and paraffins + naphthenes. Under severe Unifining conditions naphthalene is substantially eliminated and 85 to 90 percent of the methyl and dimethylnaphthalenes disappear. The concentration of "dimethyl" tetralin is less than from mild Unifining but more than that in the charge. Paraffins + naphthenes increased considerably. It thus appears that mild Unifining partially hydrogenates some of the naphthalenes to tetralins as well as olefins to paraffins. Under severe Unifining conditions additional hydrogenation of the naphthalenes to decalins as well as to tetralins takes place. The calculated hydrogen contents of the oils agree well with those obtained by Beta-Ray absorption analyses.[8]

The initial boiling point of cycle oil, *C*, was 430 F. Mild Unifining produced 20 percent of material boiling below this temperature which is probably alkylbenzenes and tetralins formed and therefore the high octane number of 101 F-1 clear is understandable. Severe Unifining produced decalins as well as alkylbenzenes and tetralins, giving 30 percent distilled at 430 F. of only 95 clear octane number; this lower octane number is probably due to the decalins. To provide further information pertaining to these conclusions, Unifining of the following components was carried out under both mild and severe conditions: methylnaphthalene, methyltetralin, ethylbenzene, and methyldecalin.

The methylnaphthalene charge stock was a diesel fuel reference grade material boiling at 464 F. and contained 0.79 percent sulfur and 200 ppm basic nitrogen. The product from Unifining was separated into four major fractions. In the order of decreasing boiling points these were first, the unconverted methylnaphthalenes; second, the partially hydrogenated methyltetralins; third, a 338 to 419 F. cut containing most of the non-aromatic product; and fourth, a small amount of low boiling alkybenzenes and their saturated derivatives. Table 4 shows the product distribution obtained.

The principal reaction under both mild and severe conditions was partial saturation of methylnaphthalenes to methyltetralins. (Methyltetralins were assumed to comprise all aromatic material in the 338 F. + fractions as determined by FIA procedure, except the naphthalene portion as determined by ultraviolet analysis.) Com-

TABLE 2
Methods Employed in Determining Compound Types

Component or Average of Components	Formula	Wt. % H_2	Method of Determination
1. Methylbenzothiophene	C_9H_8S	5.45	S Analysis
2. Naphthalene	$C_{10}H_8$	6.30	U.V.
3. Methylnaphthalene	$C_{11}H_{10}$	7.10	U.V.
4. Dimethylnaphthalene	$C_{12}H_{12}$	7.75	U.V.
5. "Dimethyl"tetralin*	$C_{12}H_{16}$	10.08	Total aromatics
6. Alkylbenzenes	$C_{11}H_{16}$	10.90	and H_2 balance
7 Aromatic olefins	$C_{12}H_{10}$	6.55	Br. No. & FIA
8. Non-Aromatic olefins	$C_{14}H_{27}$	13.96	FIA
9. Paraffins + Naphthenes	$C_{14}H_{29}$	14.85	FIA

Notes: * Average of methyl-, dimethyl-, and trimethyltetralins in cycle oil C boiling range.

TABLE 3
Analysis of Light Cycle Oil Before and After Unifining

	Charge	Run A Mild Unifining	Run B Severe Unifining
1. Methylbenzothiophene, Weight Percent	12.7	0	0
2. Naphthalene, Weight Percent	.8	.2	0
3. Methylnaphthalenes, Weight Percent	7.1	2.8	.7
4. Dimethylnaphthalenes, Weight Percent	13.4	6.0	2.1
5. "Dimethyl"tetralin, Weight Percent	39.7	55.7	45.9
6. Alkylbenzenes, Weight Percent	0	10.0	10.0
7. Aromatic Olefins, Weight Percent	4.7	.7	.5
8. Non-Aromatic Olefins, Weight Percent	3.8	.3	0
9. Paraffins + Naphthenes, Weight Percent	17.8	24.3	40.8
Calculated Weight Percent H_2	9.77	11.08	12.01
Weight Percent H_2 by Beta-Ray	9.86	11.06	11.95
Volume Percent over at 430 F.	0	20	30
Octane No., F-1 Clear	....	101	95

plete saturation of methylnaphthalenes to non-aromatic material, assumed to be methyldecalin or its isomers, was small under mild Unifining conditions but quite appreciable under severe Unifining conditions. Together these two saturation reactions accounted for the bulk of the hydrogen consumption observed in the tests.

The low boiling alkyl aromatics which could be individually determined by infrared analysis were undoubtedly derived from methylbenzothiophenes and quinolines present in the charge stock. The various isomeric C_9 aromatics can each be associated with a particular isomer of these heterocyclics. Yields of low boiling material were approximately the same under severe or mild Unifining conditions. The absence of any appreciable skeletal degradation reactions was demonstrated by the low hydrocarbon gas yield, less than 0.15 percent of feed in either case.

The methyltetralin feed employed was a 419 to 460 F. 100 percent aromatic cut from Unifining methylnaphthalene. It contained 0.05 percent sulfur and 20.8 wt. percent naphthalenes. Product distribution is given in Table 5.

Due to the absence of heterocyclic compounds, this material gave no low boiling alkyl aromatics by either mild or severe Unifining. The product consisted principally of methylnaphthalenes, unconverted methyltetralins, and a 374 to 419 F. fraction containing the non-aromatic product.

The lower boiling (374 to 397 F.) non-aromatic product from severe Unifining was further examined to see whether it consisted of methyldecalins and its isomers, or whether ring fracture had taken place to give alkylated monocyclanes. Residual aromatics were removed with silica gel and hydrogen content was determined by Beta-Ray absorption. This turned out to be 13.19 percent hydrogen as compared with 13.22 percent calculated for methyldecalin and 14.35 percent for diethylmethylcyclohexane.

It was of interest that under mild Unifining conditions there was a small back conversion of methyltetralins to methylnaphthalenes, which helped to account for the low net hydrogen consumption.

The ethylbenzene charge stock was a 100 percent aromatic material of .8718 specific gravity, boiling at 277 F. (See Table 6.) The products from mild and severe Unifining were fractionated into a benzene cut, toluene cut, ethylcyclohexane cut, and ethylbenzene bottoms. Conversion to the lower boiling aromatics and their saturated derivatives was minor, and likewise the gas make. Principal reaction was saturation of ethylbenzene to ethylcyclohexane. Under mild conditions this conversion proceeded about 10 percent and under severe conditions to about 50 percent. There was no evidence of ring fracture. Practically all the non-aromatics boiled above 266 F., well above the highest boiling octane isomer (n-C_8 H_{18}, 258 F.).

Methyldecalins were studied by Unifining technical methylnaphthalene and then hydrogenating the product over UOP nickel catalyst in a rotating autoclave. The product was distilled to obtain a 400 to 415 F.

TABLE 4

Product Distribution from Mild and Severe Unifining Technical Methylnaphthalenes

Product Distribution	Charge Stock Weight Percent	PRODUCTS PERCENT OF OIL FED, FROM Mild Unifining: Weight Percent	Mild Unifining: Volume Percent	Mild Unifining: Calculated H_2 Cons. CF/B	Severe Unifining: Weight Percent	Severe Unifining: Volume Percent	Severe Unifining: Calculated H_2 Cons. CF/B
Methane		0.06			0.10		
Ethane		0.01			0.02		
Propane		<0.01			0.01		
Butanes		0.01	0.02		—	—	
Pentane		0.02	0.03		—	—	
H_2S		0.76			0.81		
Liquid Product		101.4	106.6		102.5	111.5	
IBP—338° F.	0	3.5	4.1		3.1	3.6	
338°—419° F.	0	5.6	6.5		29.6	34.1	
419°—460° F.	0	64.9	68.0		68.2	72.0	
460°F.+ Bottoms	100	27.4	27.9		1.6	1.7	
Molecular Species							
H_2S		0.8		65	0.8		65
C_1—C_5 gas		0.1		45	0.1		80
Low boiling non-aromatics		0.5			1.0		
C_9-aromatics		0.1			tr.		
Propylbenzenes		0.9		70	2.0		50
Ethyltoluenes		2.0					
Trimethylbenzenes		tr.					
Naphthalene		0.1		—	0.2		—
Methyldecalins		2.6		115	21.2		935
Methyltetralins		63.9		1180	67.8		1250
Methylnaphthalenes	96.2	31.3		—	8.3		30
High boiling olefins	—	—		—	0.9		—
Methylbenzothiophene	3.6	tr.		—	—		—
Quinolines	0.2	—		—	—		—
Total		102.3		1475	103.2		2410
Experimental Hydrogen Consumption; CF/B		1473			2350		

TABLE 5

Product Distribution from Mild and Severe Unifining Methyltetralins

Product Distribution	Charge Stock Weight Percent	PRODUCTS PERCENT OF OIL FED, FROM Mild Unifining: Weight Percent	Mild Unifining: Volume Percent	Mild Unifining: Calculated H_2 Cons. CF/B	Severe Unifining: Weight Percent	Severe Unifining: Volume Percent	Severe Unifining: Calculated H_2 Cons. CF/B
Methane		0.007			0.01		
Ethane		0.003			<0.01		
Propane		—			—		
Butanes		0.009	0.015		0.02	0.03	
Pentanes		0.002	0.003		<0.01	<0.01	
H_2S		0.0	0.0		0.0	0.0	
Liquid Product		100.0	100.9		101.9	105.6	
IBP—419° F.	tr.	10.0	10.7		34.4	37.9	
419°—460° F.	71.2	81.8	82.4		62.6	63.2	
460° F. + Bottoms	28.8	8.2	7.8		4.9*	4.7*	
Molecular Species							
Naphthalene		1.4		—	tr.		
Methyldecalins		7.0		180	32.9		840
Methyltetralins	79.2	65.5			64.9		
Methylnaphthalene	20.8	26.1		—125	3.7		+305
High boiling olefins		0.2			0.4		
Total		100.2		55	101.9		1145
Experimental Hydrogen Consumption, CF/B		100			1233		

Notes: * 451° F. bottoms.

heart cut, which analyzed by FIA 1.2 percent aromatics, 0.8 percent olefins, 98 percent paraffins and naphthenes. Beta-Ray hydrogen content of the paraffin-naphthene portion was 13.27 percent, corresponding to an empirical formula of $C_{11}H_{20.05}$. Infrared absorption analyses gave little information about this material except that the spectrum resembled generally that of reference decalins. There are a large number of possible geometric and position isomers, involving not only the location of the methyl group on the ring and its cis-trans orientation relative to the bridging carbon atoms but also other isomeric ring structures such as substituted hydrindanes or bicycle-octanes.

No clear cut reaction was obtained by Unifining methyldecalins. Hydrogen consumption was nil. There was a slight increase of aromatic content and a spread in the boiling range. Severe Unifining gave 8 percent yield of low boiling material. This was the first evidence obtained of any ring opening; data are given in Table 7. The 270 to 288 F. fraction of this low boiling material, comprising about one-half of the total amount boiling below 400 F. was analyzed for hydrocarbon types. It contained 2 percent paraffins, 1 percent olefins, 56 percent naphthenes, and 41 percent aromatics.

This material was presented before the Atlantic City meeting of the Division of Petroleum Chemistry, American Chemical Society, September 17-21, 1956.

TABLE 6
Product Distribution from Mild and Severe Unifining Ethylbenzene
Plant 505

Product Distribution	Charge Stock Weight Percent	PRODUCTS PERCENT OF OIL FED. FROM Mild Unifining Weight Percent	Mild Unifining Volume Percent	Mild Unifining Calculated H_2 Cons. CF/B	Severe Unifining Weight Percent	Severe Unifining Volume Percent	Severe Unifining Calculated [1] H_2 Cons. CF/B
Methane		0.019			0.027		
Ethane		0.022			0.072		
Propane		0.001			0.007		
Butanes		0.006	0.009		0.009	0.014	
Pentane		0.003	0.004		0.003	0.004	
H_2S		0.008			0.008		
Liquid Product		100.3	101.9		102.4	107.5	
IBP—194° F.	0	0.6	0.6		0.8	0.9	
194°—248° F.	0.9	1.3	1.4		0.5	0.6	
248°—271° F.	0.5	7.8	8.3		44.5	48.3	
271° F+	98.6	90.5	91.4		56.5	57.9	
Molecular Species							
H_2S		tr.			tr.		
C_1—C_3 gas		0.1		—	0.1		
Benzene		0.3		—	0.3		
Cyclohexane		0.3		10	0.5		20
Toluene		0.6		—	0.1		—
Methylcyclohexane		0.7		25	0.4		15
Ethylbenzene	100	87.3			53.5		—
Ethylcyclohexane		10.7		330	47.2		1450
Olefins		0.3			0.3		
Total		100.3		365	102.4		1485
Experimental Hydrogen Consumption, CF/B		170			1340		

TABLE 7
Product Distribution from Mild and Severe Unifining Methyldecalins

Product Distribution	Charge Stock Wt. %	PRODUCTS PERCENT OF OIL FED, FROM Mild Unifining Wt. %	Mild Unifining Vol. %	Severe Unifining Wt. %	Severe Unifining Vol. %
Methane		0.004		0.010	
Ethane		0.005		0.013	
Propane		0.003		0.004	
Butanes		0.003	0.005	0.003	0.005
Pentane		0.002	0.003	—	—
Liquid Product		100.0	100.0	100.1	100.5
IBP—400 F.	2.8	2.8	2.9	8.2	8.6
400°—415 F.	72.8	73.0	73.4	83.2	83.5
415 F. + Bottoms	24.4	24.2	23.7	8.7	8.4
FIA	Vol. %				
Aromatics	1.2		3.0		3.6
Olefins	0.8		1.2		0.5
Paraffins + Naphthenes	98.0		95.8		95.9
Experimental Hydrogen Consumption, CF/B		4		40	

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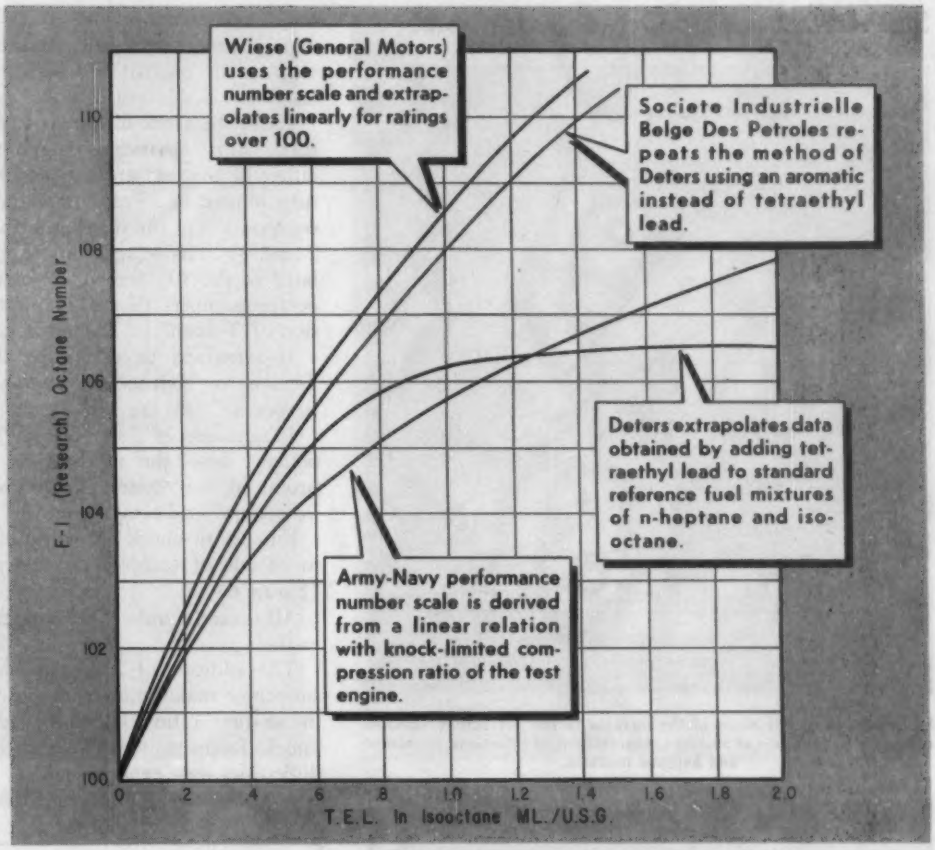
Wiese (General Motors) uses the performance number scale and extrapolates linearly for ratings over 100.
Societe Industrielle Belge Des Petroles repeats the method of Deters using an aromatic instead of tetraethyl lead.
Deters extrapolates data obtained by adding tetraethyl lead to standard reference fuel mixtures of n-heptane and iso-octane.
Army-Navy performance number scale is derived from a linear relation with knock-limited compression ratio of the test engine.
F-1 (Research) Octane Number
110
108
106
104
102
100
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
T.E.L. in Isooctane ML./U.S.G.

FIGURE 1—This graph shows how method used at Societe Industrielle Belge des Petroles gives data which agree with method proposed by Wiese better than with either of the other two methods shown.

SIBP Data Back Up Octane Extension

These laboratory findings lend support to the anti-knock scale approved tentatively by the ASTM.

P. Tritsmans and H. Vos
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Antwerp, Belgium

HOW BEST to express the anti-knock quality of fuels above 100 octane is still a very controversial subject.

The favorable reception which the G. M. formula $O.N. = 100 + \frac{PN - 100}{3}$ has received[1] has made the authors feel justified in disclosing a series of experiments carried out at the Societe Industrielle Belge Des Petroles laboratory: first because these results prove very much in favor of the G. M. scale, and secondly because they prove the possibility of obtaining in an experimental way what seems a natural extension of the existing octane scale.

In viewing the various "T.E.L. in *iso*-octane" versus "octane number" relationships (Figure 1) which have been produced in the course of time, the similarity of the curve established by the authors (SIBP-curve) and the curve derived from the G. M. formula is clearly brought out.

The idea for the SIBP-extension of the octane scale was born of the work of Deters.[2] In fact, as will be shown presently, the work of the authors and that of Deters is identical except that the authors use a high octane aromatic where Deters uses T.E.L.

Experimental—Deters obtained his extended octane scale (Figure 1) by determining the octane number of n-heptane/*iso*-octane mixtures at varying levels of T.E.L. content, and extrapolating graphically to the 100 percent *iso*-octane line.

In addition to the difficulty that the lines to be extrapolated are curved, they show the disadvantage of converging to the octane number of 106.5 at the 100 percent *iso*-octane line.

This last characteristic expresses itself particularly clearly in the ultimate "T.E.L. in *iso*-octane/octane number" relationship, which would not permit the determination of octane numbers above the 1 ml. "T.E.L. in *iso*-octane" or 106.5 octane number level.

It was felt that by following the same technique, but using a high-octane hydrocarbon instead of T.E.L. these

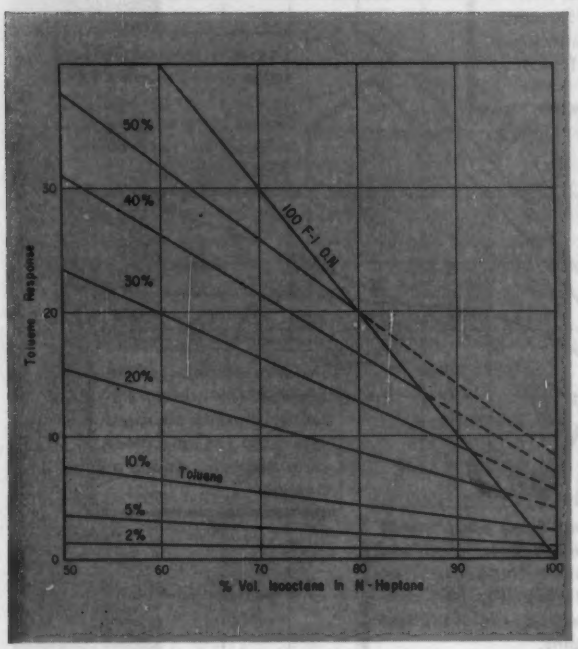

FIGURE 2—A plot is made of the increase in the F-1 octane numbers caused by the addition of various concentrations of toluene to *iso*-octane and heptane mixtures.

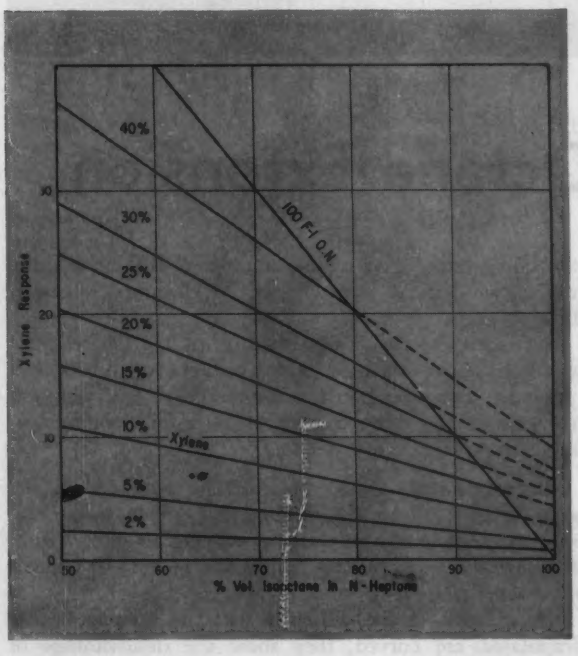

FIGURE 3—(Above) This plot for xylene was made in the same manner as that shown in Figure 2.

TABLE 1
EXTRAPOLATED OCTANE NUMBERS

Percent Vol. Toluene in iso-octane	Octane Numbers	Percent Vol. Xylene in iso-octane	Octane Numbers
2	100.6	2	100.7
5	101.3	5	101.6
10	102.4	10	103.0
20	104.2	20	105.4
30	105.6	30	107.1
40	106.9	40	108.5
50	108.0	50	109.6

handicaps could be overcome. Accordingly two distinct experiments were made, in the one Toluene was made to play the part of T.E.L. in the Deters experiment, in the other a mixture of equal parts of m- and p-Xylene.

As in the work of Deters, the octane numbers of mixtures of n-heptane/*iso*-octane with varying amounts of either of the two aromatics were determined and the results plotted in a graph of "aromatic response" versus the composition of the n-heptane/*iso*-octane mixture (Figures 2 and 3). The straight lines thus obtained were extrapolated to the 100 percent *iso*-octane line and the resulting octane numbers (Table 1) plotted against the concentration of Toluene or Xylene in *iso*-octane (Figure 4).

It remained to determine the anti-knock quality of Toluene or Xylene in *iso*-octane in terms of "T.E.L. in *iso*-octane" (Figure 5).

Elimination of the variable "Toluene or Xylene in *iso*-octane" from the two graphs (Figures 4 and 5) then produced the desired relationship between "T.E.L. in *iso*-octane" and octane number (Figure 1).

Finally, to check for continuity, the scale was applied to blends of components above and below 100 octane (Figure 6).

All octane numbers were determined on a normal CFR engine.

The addition of Xylene to mixtures of n-heptane and *iso*-octane makes the engine slow in responding to changes in air-fuel ratio. Therefore adjustments for maximum knock intensity took longer than usual, otherwise no difficulties were experienced.

A temporary guide curve for the compression ratio-

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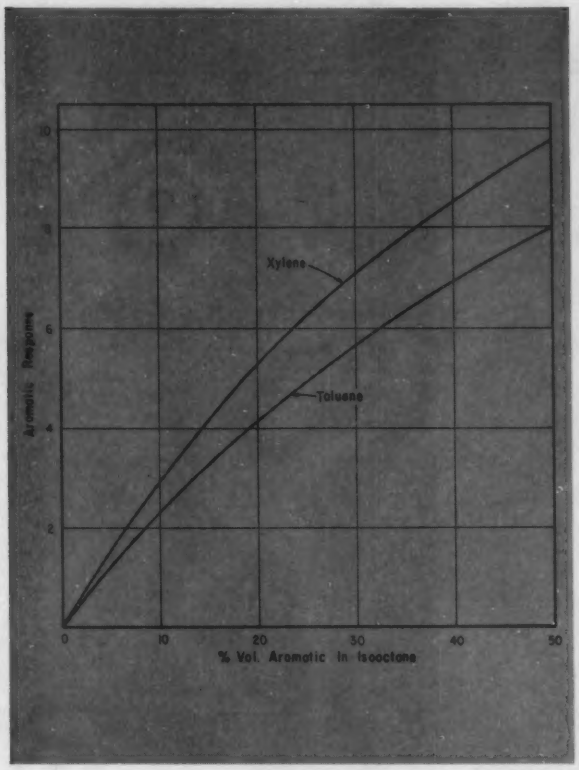

FIGURE 4—After the aromatic concentration lines have been extrapolated to 100 percent *iso*-octane, the resulting values are plotted against the aromatic concentration.

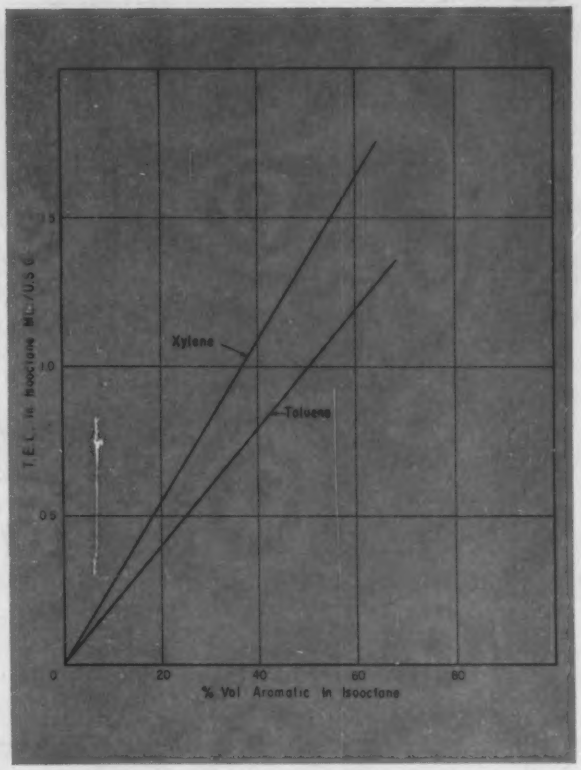

FIGURE 5—Here is the quantity of tetraethyl lead which would be required to give the same knocking characteristics as the aromatics in *iso*-octane.

micrometer setting was established starting from the position for octane number 100 and determining the micrometer setting for the same knockmeter reading at various T.E.L. in *iso*-octane levels.

Discussion—The octane scale was developed as a temporary aid in planning purely local operations. Its merits have therefore never been viewed from any other angle than that of future local requirements. These it satisfied, in that:

- It was continuous, i.e., it did not produce a noticeable break at octane number 100.
- It was progressive, i.e., it did not level off at the higher "T.E.L. in *iso*-octane" levels as did the Deters scale.
- It was derived from actual octane determinations, and both aromatics yielded the same scale.

That the scale might be of value beyond the local scene was not thought of until the authors learned of the Wiese scale.

As in the latter case, the relationship between octane number above 100 and performance number is practically a straight line. And since it lies below the Wiese scale, the discontinuity at 100 octane is even less pronounced. A tentative extrapolation would yield an octane number of about 119 at 6 ml. TEL/USG.

ACKNOWLEDGMENT

The authors wish to thank P. Caluwé for obtaining the large number of octane ratings required for this work, and to express their appreciation to the management of Société Industrielle Belge des Pétroles for permission to print this article.

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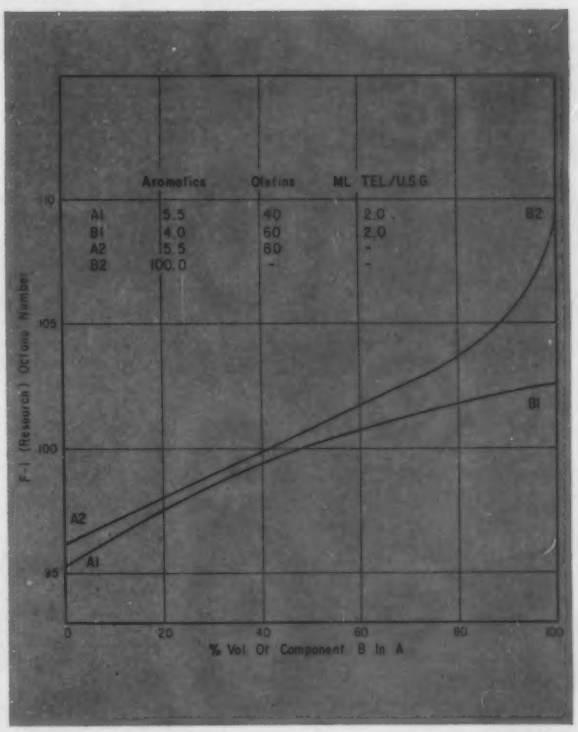

FIGURE 6—To show the continuity of the method in the 100 octane range, it was applied to several mixtures.

ml TEL	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	ml TEL
0.0	100.0	100.1	100.3	100.4	100.5	100.7	100.8	100.9	101.1	101.2	0.0
0.1	101.3	101.4	101.6	101.7	101.8	101.9	102.0	102.1	102.3	102.4	0.1
0.2	102.5	102.6	102.7	102.8	102.9	103.0	103.1	103.2	103.3	103.4	0.2
0.3	103.5	103.6	103.7	103.8	103.9	104.0	104.1	104.2	104.3	104.3	0.3
0.4	104.4	104.5	104.6	104.7	104.8	104.9	104.9	105.0	105.1	105.2	0.4
0.5	105.3	105.4	105.4	105.5	105.6	105.7	105.7	105.8	105.9	106.0	0.5
0.6	106.0	106.1	106.2	106.3	106.3	106.4	106.5	106.5	106.6	106.7	0.6
0.7	106.7	106.8	106.9	106.9	107.0	107.1	107.1	107.2	107.3	107.3	0.7
0.8	107.4	107.5	107.5	107.6	107.6	107.7	107.8	107.8	107.9	108.0	0.8
0.9	108.0	108.1	108.1	108.2	108.2	108.3	108.4	108.4	108.5	108.5	0.9
1.0	108.6	108.6	108.7	108.7	108.8	108.8	108.9	109.0	109.0	109.1	1.0
1.1	109.1	109.2	109.2	109.3	109.3	109.4	109.4	109.5	109.5	109.6	1.1
1.2	109.6	109.7	109.7	109.8	109.8	109.9	109.9	109.9	110.0	110.0	1.2
1.3	110.1	110.1	110.2	110.2	110.3	110.3	110.4	110.4	110.4	110.5	1.3
1.4	110.5	110.6	110.6	110.7	110.7	110.7	110.8	110.8	110.9	110.9	1.4
1.5	111.0	111.0	111.0	111.1	111.1	111.2	111.2	111.2	111.3	111.3	1.5
1.6	111.4	111.4	111.4	111.5	111.5	111.5	111.6	111.6	111.7	111.7	1.6
1.7	111.7	111.8	111.8	111.9	111.9	111.9	112.0	112.0	112.0	112.1	1.7
1.8	112.1	112.1	112.2	112.2	112.2	112.3	112.3	112.4	112.4	112.4	1.8
1.9	112.5	112.5	112.5	112.6	112.6	112.6	112.7	112.7	112.7	112.8	1.9
2.0	112.8	112.8	112.9	112.9	112.9	113.0	113.0	113.0	113.0	113.1	2.0
2.1	113.1	113.1	113.2	113.2	113.2	113.3	113.3	113.3	113.3	113.4	2.1
2.2	113.4	113.4	113.5	113.5	113.5	113.6	113.6	113.6	113.7	113.7	2.2
2.3	113.7	113.7	113.8	113.8	113.8	113.9	113.9	113.9	113.9	114.0	2.3
2.4	114.0	114.0	114.1	114.1	114.1	114.1	114.2	114.2	114.2	114.3	2.4
2.5	114.3	114.3	114.3	114.4	114.4	114.4	114.4	114.5	114.5	114.5	2.5
2.6	114.5	114.6	114.6	114.6	114.6	114.7	114.7	114.7	114.7	114.8	2.6
2.7	114.8	114.8	114.9	114.9	114.9	114.9	114.9	115.0	115.0	115.0	2.7
2.8	115.0	115.1	115.1	115.1	115.1	115.2	115.2	115.2	115.2	115.3	2.8
2.9	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5	115.5	2.9

ml TEL	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	ml TEL
3	115.5	115.7	116.0	116.2	116.4	116.6	116.8	117.0	117.2	117.3	3
4	117.5	117.7	117.9	118.0	118.2	118.3	118.5	118.6	118.8	118.9	4
5	119.1	119.2	119.3	119.5	119.6	119.7	119.9	120.0	120.1	120.2	5

Conversion table makes it easy to . . .

Change Iso + TEL to Octane Numbers

If you work with octanes over 100, you will want to keep this conversion table handy. It represents the method of conversion suggested by the American Society of Testing Materials.

IN JUNE of this year it is expected that the D-2 Committee of the American Society for Testing Materials will approve an extension of the octane number scale. An extension already is tentatively approved by the committee. It rates fuels with octane numbers over 100 by comparing their knock intensity with test fuels containing tetraethyl lead in *iso*-octane.

The octane numbers tentatively assigned to *iso*-octane with tetraethyl lead are given in the accompanying table. If the information in this table meets with no serious objections before the meeting of the D-2 Committee, it is expected to be incorporated into the present ASTM Motor Method D 357 and the ASTM Research Method D 908.

Any comments on the reference fuels should be communicated to W. T. Gunn, secretary; ASTM Committee D-2 on Petroleum Products and Lubricants, Room 2040, 50 West 50th Street, New York 20, New York.

The values in the table were obtained from the relation given as follows:

$$\text{Octane Number} = 100 + \frac{28.28\,T}{1.0 + 0.736\,T + \sqrt{1.0 + 1.472\,T - 0.035216\,T^2}}$$

Where:

T = ml TEL per U. S. gallon in *iso*-octane.

Study Catalyst Behavior With Isotopes

Using this new tool, data never before available can now be gathered simply and rapidly.

V. P. Guinn and H. R. Lukens, Jr.
Shell Development Company
Emeryville, Calif.

AMONG THE MANY USEFUL applications of radioisotope techniques in the petroleum industry are studies of catalyst behavior such as mixing and aging in fluid catalytic cracking units. Shell Development Company and Shell Oil Company have carried out a large number of such studies but space does not permit the discussion of each study. Therefore, the considerations which are required for and are common to all of the tests will be discussed.

Catalyst mixing[5] is the most simple type of test from a physical standpoint. The pattern of such a test is: tag a small (5-10 pound) batch of catalyst, inject it into a catalytic cracking unit, remove samples (usually one kilogram samples) from a number of zones simultaneously and at chosen intervals and count the samples. From the counting data the relative concentration of tagged catalyst in the zones sampled at given times and, thus, the catalyst mixing behavior of the unit is determined.

The isotope chosen to serve as the tracer[1,2] is the first consideration of such a test.

- The isotope must have a half-life which permits adequate use-time but should not be long enough to permit the possibility of permanently contaminating equipment.
- The isotope should be a gamma-emitter since it is desirable to monitor the tracer through heavy-walled vessels. In addition gamma-rays may be counted with great sensitivity and are easily examined by pulse height analysis.

An isotope of high specific activity is desirable in order to minimize metal contamination of the catalyst (particularly important in aging studies).

- The isotope must adsorb strongly and evenly on the catalyst and so remain under conditions met within the catcracker.

It has been found that the isotopes Ce^{144}, Cr^{51}, and Sc^{46} meet the foregoing requirements satisfactorily.

Quantity Considered—*Quantity of isotope* to use is the next consideration. This is defined by the extent to which it will be diluted in the unit (60 tons of catalyst in a small unit, 900 tons in a larger unit), the sensitivity of sample counting methods and safety considerations.

Samples obtained in mixing tests may be directly counted and we may therefore use samples essentially as large as we wish for the very sensitive dip-counting method. We use a two-inch sodium iodide crystal photomultiplier tube scintillation counter combination. A one kilogram sample of catalyst tagged with one of the above isotopes may be counted with about 10 percent over-all efficiency using this counter in the dip arrangement. The background of the counter when shielded is about 200 counts per minute. If we accept as a minimum accuracy a standard deviation of ± 10 percent and a maximum counting time of 30 minutes, we need to have 38 counts per minute net or 380 disintegrations per minute in our sample. The minimum concentration of tracer is therefore 0.38 disintegrations per minute/gram. If the sample size is 2.5 kilograms of catalyst the concentration sensitivity is 0.2 disintegrations per minute/gram. We are, of course, speaking of gamma disintegrations per minute—an important distinction since the gamma yield is different for each of the isotopes mentioned.

The dilution of 1 millicurie of radioactivity with 500 tons of catalyst with result in a final concentration of 5 disintegrations per minute/gram or about 13 times the minimum needed for ± 10 percent accuracy on one kilogram samples. In a mixing study this would allow us to just observe the isotope (S. D. ± 100 percent) as soon as its concentration in a given zone reached 1 percent of the final well-mixed value.

Tagging the Catalyst—An aqueous solution containing the tracer (form: MCl_3), adjusted to a pH of four with HCl is prepared in sufficient volume to cover the catalyst to be tagged. The catalyst and solution are mixed until essentially all of the tracer is removed from solution (as determined by counting aliquots), and mixing is continued for an additional hour to ensure even distribution of the isotope on the catalyst. The catalyst is allowed to settle and the supernate decanted. The catalyst is dried at 120-150 C. until its moisture content is reduced to its normal value.

The dried catalyst is packaged in polyethylene bags, shielded and shipped to the test site. At the test site

About the Authors

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it is transferred to a steel injection vessel which may be pressurized to permit a rapid injection. The catalyst is then injected into the unit. The vessel is monitored during this operation to determine the rapidity and completeness of injection.

Safety considerations which include the use of monitoring, shielding, trays to contain spills and controlled atmospheres (particularly in packaging the tagged catalyst), are necessary through the point of catalyst injection. Once injected, the tagged catalyst is quickly diluted to a non-hazardous concentration. For example, five millicuries of radioisotope when diluted with 500 tons of catalyst has a concentration of about 10^{-5} μc per gram. The maximum permissible concentrations in the human body of Ce^{144}, Cr^{51} and Sc^{46} are 5, 390, and 6μc respectively. Thus, if the least tolerable isotope, Ce^{144}, were the catalyst tag in our example, it would be necessary for a person to ingest 1000 pounds of catalyst to reach a maximum permissible concentration in his body.

Aging Studies—Aging studies[2] to determine how originally fresh catalyst changes with time spent in a catcracker follow a pattern similar to that of the mixing studies. That is, a batch of catalyst is tagged, injected into the unit, sampled, etc. This type of test differs from a mixing test in that—

- Larger batches of catalyst (up to 100 pounds) are tagged,
- More isotope is required,
- Sampling does not begin until the tagged material is well mixed (on the order of one hour after injection) and
- Samples are separated by sink-float techniques before counting.

The sink-float technique described by Wilson, et al[2] allows a catalyst sample to be separated into fractions according to catalyst property. Thus, if the sample is suspended in a binary mixture (e.g., CCl_4 and $C_2H_2Br_2$) adjusted to the catalyst mean skeletal density and the suspension is centrifuged, the particles of high skeletal density will be separated from those of low skeletal density. If before suspension and centrifugation the particles are about one-half saturated with water, the separation, because the small pores are preferentially filled with water, becomes a function of pore radius. If the catalyst is fully saturated with water and then separated, the separation is governed by pore volume. Of course each fraction obtained by the sink-float separation may in turn be separated.

The value of the above properties which the injected tagged catalyst possesses at a given time in the unit is determined by counting the separated fractions of a sample taken from the unit at that time. In this manner it is possible to follow the catalyst changes occurring with time spent in the unit.

The sink-float separations are somewhat tedious and result in small (3-5 gram) samples. These samples are counted in a scintillation well-counter. A two-inch NaI(TI) crystal with a ¾-inch inside diameter by 1½-inch hole is used. The counter has an overall efficiency greater than the dip-counter (Ce^{144} —85 percent, Cr^{51} —60 percent, Sc^{46} —30 percent and has a shielded background of about 200 counts per minute. If we again wish a standard deviation of ±10 percent in 30 minutes, and wish to use Ce^{144}, we need a total of 45 γ disintegrations per minute in our samples. If our samples weigh 5 grams, then the concentration sensitivity is 9 γ disintegrations per minute/gram.

Although the dip-counter is more concentration-sensitive than the well-counter by a factor of 25, it is not necessary to use 25 times more activity in an aging study than in a mixing study since the latter is concerned with concentrations less than that at complete mixing and the former is not. The aging studies may require up to several months to complete. Therefore it is necessary to consider isotope decay and the fact that, because of catalyst losses from the unit which are replaced with fresh catalyst, there will be isotope dilution beyond the unit's inventory of catalyst. An aging study usually requires less than ten times more isotope than a mixing study in a given unit.

Rate of Catalyst Loss Measured—It is possible while carrying out an aging study to measure the rate of catalyst loss through the regenerator stack.[5] The stack gases are continuously sampled and passed through fiber-glass filters which effectively collect the catalyst particles contained in the stack gas. Such collections are made at chosen intervals after injecting the tagged catalyst into the unit and the samples counted. The counting rate of the collected samples indicates the relative rate of loss of catalyst as a function of time spent in the unit.

Multiple Tagging—It is desirable to compare the aging behavior of one catalyst with another. It is not possible to do this satisfactorily with consecutive aging studies since cat-crackers do not operate at a given set of conditions for a long enough period. Therefore such comparisons must be made simultaneously. It is possible to do this by labeling each of the catalysts to be studied with a different (γ radiation energy) isotope.[3,4]

The pattern of such a comparison study is like that of an aging study; i.e., each catalyst tagged with its isotope is injected simultaneously into the unit, samples are taken and separated by sink-float technique and the samples are counted. However, it is necessary to use a pulse height analyzer to determine the count of each isotope present in a sample. We have been able to make simultaneous determinations of the isotopes used in triple comparison studies (Ce^{144}-0.13 Mev γ, Cr^{51}-0.32 Mev γ, and Sc^{46}-0.89, 1.12 Mev γ) with a multi-channel analyzer. This particular analyzer has five flexible channels. Since the channels are not fixed, each may be arranged to cover any desired portion of the γ energy range being presented to the instrument. Thus the channels may be chosen to give a maximum amount of counts for each isotope in its own channel with a minimum of interference from the other isotopes.

The simplicity and rapidity with which hitherto unavailable information has been gained has made the described techniques of value in refinery research.

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[4] "Simple Instrumentation Determines Several Simultaneous Radioactivities" by J. Kohl, R. E. Nather and V. P. Guinn, Nucleonics, 14, No. 10 (1956).

[5] "Use of Tracers in Refinery Studies. Part I. Catalyst Mixing Patterns in Commercial Catalytic Cracking Units" by E. Singer, D. B. Todd, and V. P. Guinn, presented at the ACS Dallas meeting April 1956.

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New Solutions for Electrical Problems

Here's a new short cut approach method to electrical power and control problems.

Herbert Argintar
James P. O'Donnell, Consulting Engineer
New York

PLANT ENGINEERS worried about distribution line voltage at a new variable-load substation can solve the problem with simple arithmetic—even if the unit is "out in the sticks" at the end of a complex system. The same method can solve the miniature extreme problem such as circuiting a group of highly sensitive relays for an involved process control or automation circuit. For 60 years, telephone engineers have known this exceptionally simple method and have applied it to their maze of networks. It's called Thevenin's theorem.

In terms of practically all industrial circuits, the theorem fundamentally is this: At any particular branch of a circuit, the circuit before the branch may be represented by a simple series circuit consisting of a voltage source and an impedance. The voltage source is equal to the open circuit voltage at the branch (i.e., the voltage value at the "line side" of the branch when the load is disconnected). The series impedance is equal to the impedance measured at the open circuit, "looking back" into the circuit (i.e., the impedance that would be measured at the branch, "line side," with the load removed, and voltage sources replaced with equivalent impedances). The general proof of the theorem is presented at the end of this paper.

There are technical limitations to the theorem's application. The circuit must be "steady state" and it must have bilateral impedances and voltage sources. Consequently, it can't be used on "electronic" circuits with vacuum tubes, etc. But, it is applicable to "power" circuits.

As an example, to illustrate the theorem's application in detail, consider a plant generator supplying the load, Z_2 which is the load impedance at one plant building, and Z_L, another load, in a different area, which is to be investigated. Note, a 60-cycle, constant voltage generator is a "bilateral" voltage source, unlike a radio tube, for instance, or a selenium rectifier. Also, the transformer substations, are "bilateral" impedances, for the current can flow identically either way. And also note, this is a "steady state" network. There are no "pulses," or electronic "pips" being generated in the power house, nor are we considering sudden switching phenomena.

If we "lump" the distribution lines to each load above into one impedance, Z_1 and Z_3, respectively, it is possible to draw a schematic diagram of the plant system. This is shown in Figure 1. From Figure 1, and particularly the terminal points "a"-"b", we can develop Figure 2, the equivalent circuit described in the theorem.

First to find the "value of the series impedance" we "remove" the subject load impedance from the circuit (Figure 3); replace the generator (voltage source) by its equivalent impedance (Figure 4); and measure the impedance of the circuit at points "a-b", by "looking into" the circuit at "a-b".

Z_1 and Z_g in series add up to $(Z_1 + Z_g)$. These, though, are in parallel with Z_2. Therefore, the

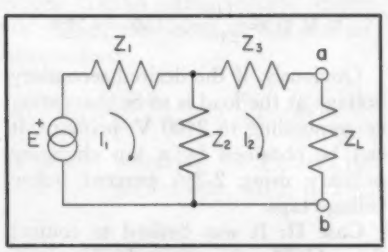

FIGURE 1—Schematic diagram of plant distribution lines.

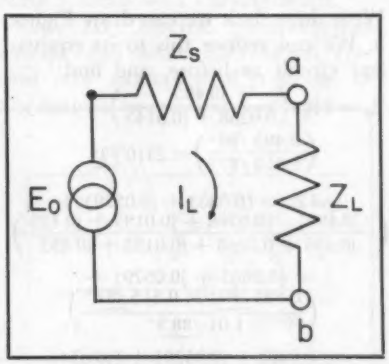

FIGURE 2—Equivalent circuit based on Thevenin's Theorem.

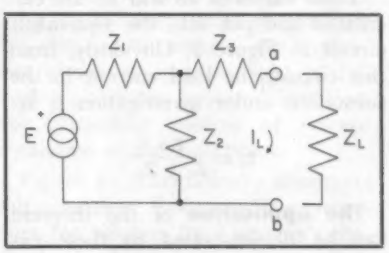

FIGURE 3—Subject load impedance "removed" from the circuit.

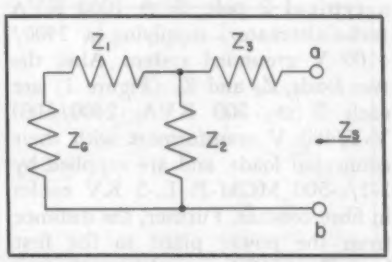

FIGURE 4—Generator replaced by its equivalent impedance.

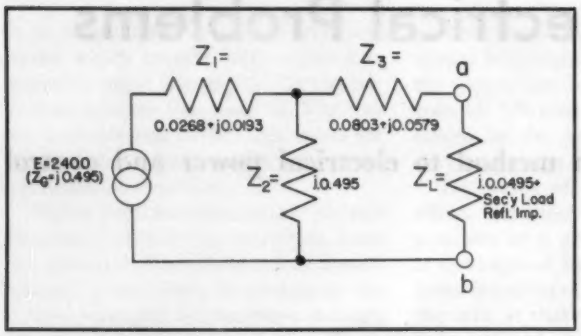

FIGURE 5—Equivalent circuit for Case 1 example.

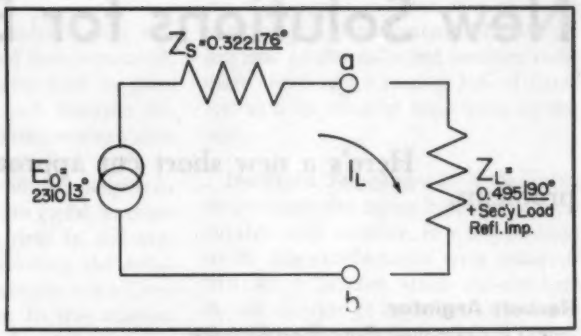

FIGURE 6—Final equivalent circuit for Case 1 example.

equivalent impedance at the terminals of Z_2 is:

$$\frac{Z_3\,(Z_1+Z_g)}{Z_3+(Z_1+Z_g)}$$

This equivalent impedance is in series with Z_3. Therefore, "looking into" "a-b" terminals we see an equivalent impedance, Zs which is:

$$Z_s = Z_3 + \frac{Z_3\,(Z_1+Z_g)}{Z_3+(Z_1+Z_g)}$$

Of course, the value of the equivalent "open circuit voltage at the branch" (terminals "a-b") is merely the "voltage divider" voltage across Z_2, since on "open circuit" (Figure 3) no current flows in Z_3. Thus the open circuit voltage Eo, is:

$$Eo = E\frac{Z_2}{Z_1+Z_2}$$

These values of Zs and Eo are calculated and put into the equivalent circuit in Figure 2. Obviously, from this circuit, the load current in the substation under investigation is I_L:

$$I_L = \frac{Eo}{Z_s+Z_L}$$

The application of the theorem can be demonstrated by these explaining examples:

CASE 1: Assume the generator is a typical 2 pole, 3 ∅ 1000 KVA turbo-alternator, supplying a 2400/4160 V grounded system. Also, the two loads, Z_2 and Z_L (Figure 1) are each 3 ∅, 500 KVA, 2400/4160 V-Y/480 V transformers with their connected loads, and are supplied by 3-1/c-500 MCM-P. L.-5 KV cables in fibre conduit. Further, the distance from the power plant to the first load, Z_2 is 500 feet; and from there it is 2500 feet to the subject load Z_L. It can also be assumed that the only impedances of consequence are the generator, lines, transformers, and the transformer secondary loads reflected back in the primary.

Suppose we want to find the terminal voltage at Z_L, for all loads on the substation, when the first substation Z_2 is unloaded.

The Solution first requires assigning correct values to the elements of Figure 1. This actually represents one of the three balanced phases.

From catalog data we determine:

(a) **Generator** Subtransient Reactance is 8.6 percent. Converted to ohms,

$$Z_g = \frac{8.6 \times (2.4)^2 \times 10}{1000} = j0.495 \text{ ohms}$$
(R_g is negligible).

(b) **Transformer** reactance is 4.3 percent. Converted to ohms,

$$Z_3 = Z_L = \frac{4.3 \times (2.4)^2 \times 10}{500}$$
$= j0.495$ ohms (R_g is negligible).

(c) **Cable** X_L per 1000 ft. = j0.0386 ohms, and $r_{a.c.}$ per 1000 ft. = 0.0535 ohms.

Thus, $Z_1 = 0.0268 + j0.0193$ ohms and $Z_3 = 0.0803 + j0.0579$ ohms

With these data we can draw Figure 5. We can reduce this to its equivalent circuit as before, and find:

$$E_o = 2400\left(\frac{j0.495}{0.0268+j0.5143}\right) = 2400 \times \left(\frac{0.495\ /90°}{0.515\ /87°}\right) = 2310\ \underline{/3°}$$

$$\text{and } Z_s = (0.0803+j0.0579) + \left(\frac{(j0.495)\ \ (0.0268+j0.0193+j0.495}{j0.495+0.0268+j0.0193+j0.495}\right)$$

$$= (0.0803+j0.0579) + \left(\frac{0.495\ /90° \times 0.515\ /87°}{1.01\ \underline{/88.5°}}\right)$$

$$= (0.0803+j0.0579) + (j0.254)$$
$$= 0.0803 + j0.312 = (R_s + jX_s)$$
$$= 0.322\ \underline{/76°}$$

This develops the final equivalent circuit of Figure 6.

We can now find the terminal voltage at the substation, Z_L, for any load. If the power factor were 80 percent, the vector diagram for solving for Vab would be as in Figure 7.

A simple way to solve this typical "voltage drop" vector diagram is to change all vectors into rectangular coordinates and arithmetically add or subtract, as shown in Figure 8.

Thus, if we assume a load of 100A at 80 percent lagging power factor, we can create the structure of the vector diagram in Figure 7; compute its coordinate values in Figure 9; and assign the computed voltage value back into Figure 7. This procedure is based upon knowledge of the load demand. The alternative approach, when the load demand varies, is to calculate the equivalent impedances of the loads, and solve for the line current. This is done in Case III.

The computed value of V_L = (Vab) = 2285 /—0.3°. The phase shift between generator and terminal voltage is negligible. However, the voltage drop on the line with the 100A @ 80 percent p.f. load is 2400-2285 = 115. This can be more meaningful if stated as regulation, that is, as percent of the generator supply.

Thus we conclude,

$$\%\ \text{V. D.} = \frac{115}{2400} \times 100 = \underline{4.79\%}$$

Obviously, if the desired secondary voltage at the load is to be that rating corresponding to 2400 V. primary, it can be obtained by a tap changing primary using 2-2½ percent below voltage taps.

Case II: It was desired to control three 440V motors with 110V relays. Assigned to each motor was a 110V,

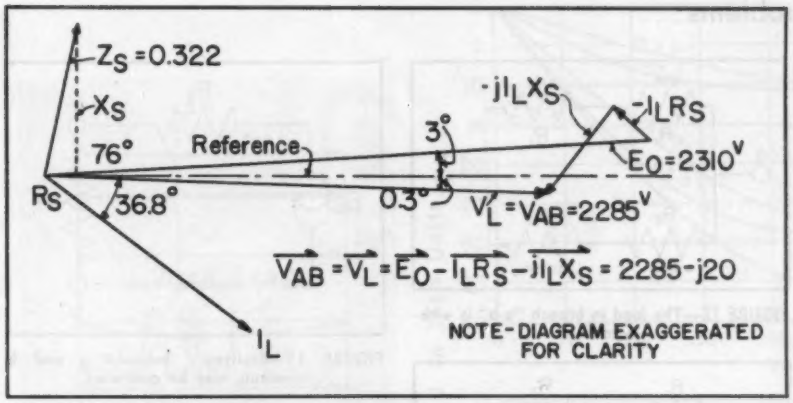

FIGURE 7—Vector diagram for solving Vab.

	+A	- A	+jB	-jB
E_0	2310	—*	—	—
IR	—	6.4	4.8	—
IX	—	18.7	—	24.9
V_L	2310	25.1	+j4.8	24.9

*NEGLIGIBLE

FIGURE 8—Easy way to solve the vector diagram.

0.25A relay. As shown in Figure 9, the relay supply voltage was obtained from the 440V supply by means of a 440V voltage divider.

The Problem was to determine suitable resistors for the voltage divider. Since the voltage across any one relay would rise when it was used alone, because the combined resistance of the tap would increase, it was determined that 130 volts was the maximum safe voltage. This would, of course, create a proportionate rise in current of 18 percent in that particular relay. Thus, one relay alone would draw 0.295 amp. However, all three together draw $3 \times 0.25 = 0.75$A.

Obviously, the voltage divider must supply a minimum of 110V output (when all relays are energized) and a maximum of 130V output (when a single relay is used). The relays may be considered a variable load, and Thevenin's Theorem applied to the problem. Accordingly, Figure 10 may be prepared.

In this case the circuit regulation is controlled by the parallel resistors of Figure 10. The voltage regulation from 110V to 130V is 20V, and the corresponding current change is 0.75-0.295 = 0.455A. In other words, when the current in the circuit increases 0.455A, the voltage drops 20V. Thus, the value of R_{oc} can be expressed as:

$$(a)\ R_{oc} = \frac{R_1R_2}{R_1 + R_2} = \frac{20}{0.455} = 44 \text{ ohms}$$

Further, referring to Figure 10, when the load current, (I_L), is, say, 0.75A, then

$$E_o = 0.75\ (R_{oc}) + 110$$
$$= 0.75\ (44) + 110$$
$$= 33 + 110 = 143\text{V}$$

Note, this also proves true at the minimum load condition. Thus, when the load current is 0.295A,

$$E_o = 0.295\ (44) + 130 = 13 + 130$$
$$= 143\text{V}$$

From this we can write another equation for the unknown R_1 and R_2, namely:

$$(b)\ E_o = 143 = \frac{R_2}{R_1 + R_2}(440)$$

Combining equations (a) and (b) as a pair of simultaneous equations, we have:

$$(a)\ R_1R_2 = 44\ (R_1 + R_2)$$
$$(b)\ R_2 = 0.325\ (R_1 + R_2)$$

and substituting (b) into (a), we derive

$$R_1 = \frac{44\ (R_1 + R_2)}{0.325\ (R_1 + R_2)} = 135 \text{ ohms}$$

and using this value in equation (b)

$$R_2 = \frac{0.325\ (135)}{(1\text{-}0.325)} = 65 \text{ ohms}$$

Comment should note that this case illustrates the "voltage divider" characteristic of problems solved by Thevenin's theorem, a characteristic which simplifies investigations of existing systems with varying loads.

Case III: Electric transportation systems and some distribution systems are examples of systems in which more than one substation is placed along the system between the initial generating point and the terminal point. In the former case, a fixed load of varying position, and sometimes a varying load in many places, can occur between two substations. In the latter case, a varying load at a fixed point between two substations is a common feature. And in both cases, substation voltage may vary. Thevenin's theorem is very adaptable and well suited to the investigation of those conditions mentioned. The following situation illustrates an application for a particular transmission line.

Two transformer substations, 720 feet apart supplied a load over a pole line of number 1/0 copper conductors. One transformer operated at 230 volts and the other at 220 volts. The load which was located 430 feet from the 230 volt station varied from 1¾ ohms to ¾ ohms as the equivalent ohmic loads from light to full load. This system required investigation, including analysis of voltage regulation at the load point.

Figure 11 schematically illustrates this situation. Following the procedure for solution by Thevenin's theorem, the load in branch "a-b" is withdrawn, and the open circuit volt-

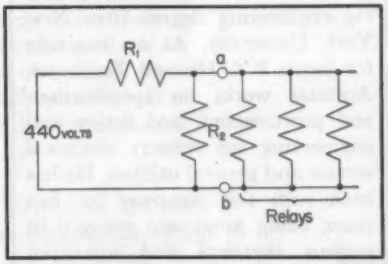

FIGURE 9—Diagram of three 440V with 110V relays.

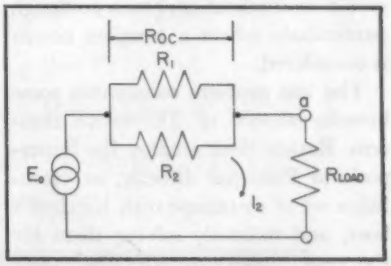

FIGURE 10—Relays are considered a variable load.

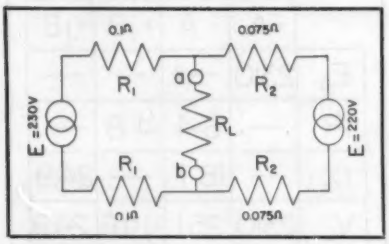

FIGURE 11—Schematic diagram of Case III.

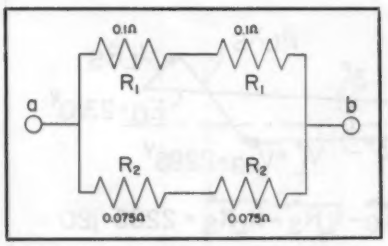

FIGURE 12—The load in branch "a-b" is withdrawn.

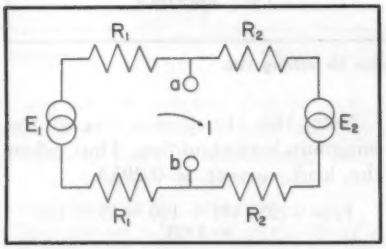

FIGURE 14—Equivalent circuit for voltage calculation.

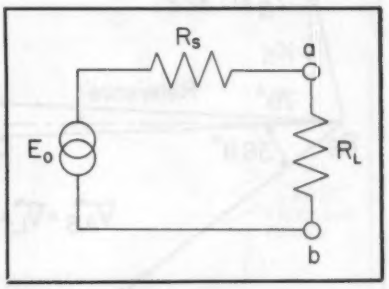

FIGURE 13—Resistance between a and b terminals may be computed.

age is determined by subtracting the necessary volt drop from the 230 volt station. According to Figure 12 this is as follows:

$$I = \frac{E_1 - E_2}{2(R_1 + R_2)} = \frac{10}{2(0.175)} = 28.6 \text{ amps}$$

(Incidentally, the value of 28.6 amps is the line circulating current, which is produced by transformer 1, in an attempt to increase the magnetizing current of transformer 2.)

The resistance between a and b terminals is computed with the aid of Figure 13 as follows:

$$R_o = \frac{2(R_1)\ 2(R_2)}{2(R_1 + R_2)} = 0.0858 \text{ ohms}$$

The equivalent circuit of Figure 14 is now constructed, and the voltage at the load determined as follows:

$$E_L = \frac{R_L}{R_o + R_L} E_o = \frac{R_L\ (224.28)}{0.0858 + R_L}$$

Thus, by using this "voltage divider" expression, the load voltage, for all load values, is very easily and simply obtained. For instance, at 75 percent full load, the voltage would be:

$$E_L = \frac{(1)\ (224.28)}{1.0858} = 208 \text{ volts}$$

These examples illustrate situations familiar to many engineers, some of whom have solved the problem with complicated methods, while others have used the same or similar method shown. These examples merely indicate a methodical approach to design particularly where a complex circuit is considered.

The last problem exemplifies some broader aspects of Thevenin's theorem. Rather than employ the Superposition Principal directly, or establish a set of equations with Kirchoff's laws, and tediously solving them for the result, one may use Thevenin's theorem for a direct and simple approach for analysis.

The results obtained by solving the last example by the three methods described above indicate the accuracy of the method. They are tabulated as follows, for the case of load voltage at 75 percent full load:

METHOD	SOLUTION
Kirchoff's Laws	206.5 volts
Superposition	205.2 volts
Thevenin's Theorem	207.0 volts

About the Author

HERBERT ARGINTAR received an electrical engineering degree from City College of New York in 1947, and he has completed three years of study towards a mechanical engineering degree from New York University. As an engineer for James P. O'Donnell, Engineers, Argintar works on specifications and procurement, and design and engineering for refinery electrical service and general utilities. He has been with this company for five years, being previously engaged in various chemical and industrial projects.

Thevenin's theorem, which was originally developed by communication engineers, will find many applications in the power field. It is simple to use, and provides accurate results. Its use, however, is limited to finding electrical relations in one particular branch of a network, but in compensation permits this branch to be completely independent of the preceding network, and vice versa. In addition its use has been expanded to almost any power system which can be represented by single circuit diagrams.

Proof of Theorem: Given a circuit as described in the statement of the theorem, with voltage sources, E_1, E_2 . . . . E_n and impedances Z_1, Z_2 . . . . Z_n, containing Z_k, through which the current is to be found. When Z_k is removed from the circuit, the branch current will be zero, and the terminal voltage, Eko. A voltage of equal magnitude, but opposite polarity can be placed in the branch and circuit conditions will remain unchanged so far as open circuit conditions are concerned.

The current distribution in the network is now determined by the N voltage and Z impedances, and the additional voltage, Eko. However, in branch K, the current is zero. But according to Helmholtz's Superposition theorem, the current distribution in branch K, with all the voltage sources replaced by their equivalent impedances, must be equal and opposite to the original in branch K. Thus, the current in the branch originally must be equal to the current that would flow if all the voltage sources were replaced by their equivalent impedances, and a voltage source introduced in branch K which was equal and opposite to the open circuit voltage. ##

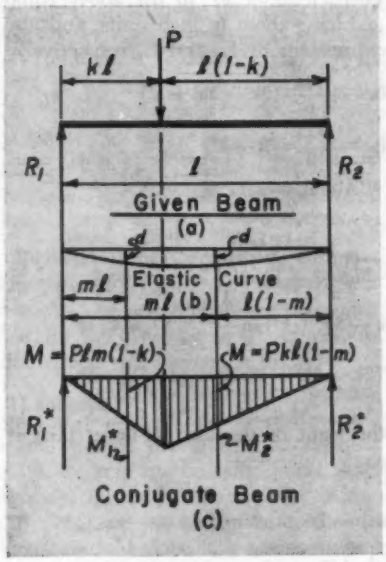

FIGURE 11—Given and Conjugate beam under concentrated load.

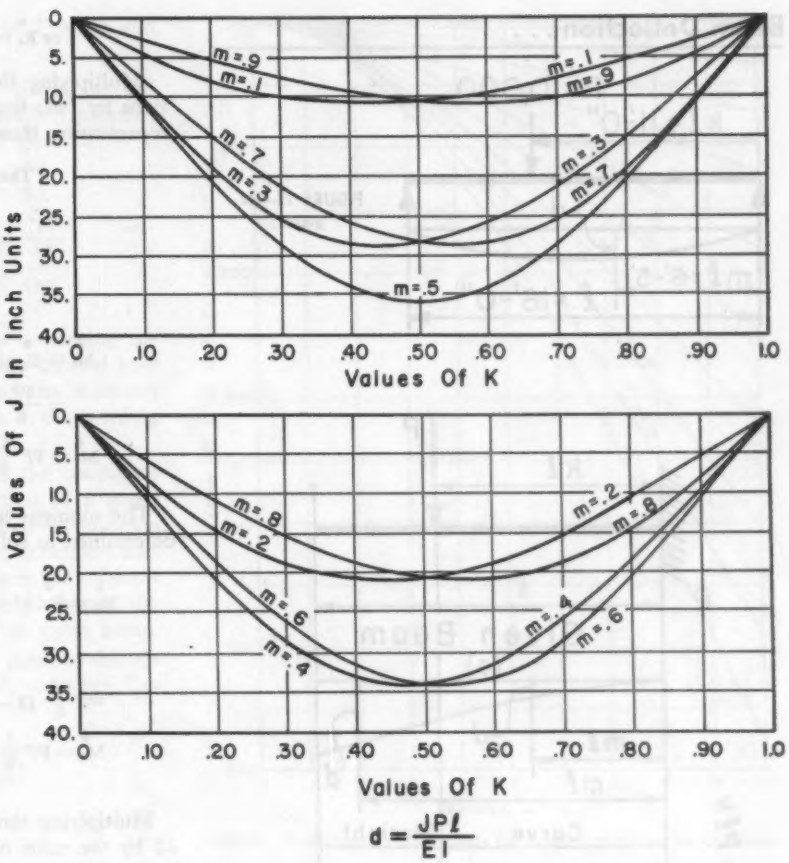

FIGURE 12—Deflection coefficients for concentrated load on simple beam.

$$d = \frac{JPl}{EI}$$

Easy Methods to Get Beam Deflection

Concentrated loads for simple and cantilever beams are no problem with this method of determining deflection.

Charles H. Fork
Ralph M. Parsons Company
Los Angeles

THE PREVIOUS part of this series described simple methods of determining the area of moment diagrams and the deflection at any point of a simple beam reacting to a uniform load. This article will describe methods for determining the deflection at any point of a simple beam reacting under a concentrated load and the deflection of a cantilever beam when a concentrated load is applied at any point over the span.

Deflection of Simple Beam—To determine the deflection at any point of a simple beam reacting under a concentrated load, the moments must first be derived.

The moment to the left of the load (Figure 11c) is determined as follows:

$$R_1^* = \frac{Pl^2}{2}(k - k^2) \times \frac{l}{3}(2 - k)/l$$

$$= \frac{Pl^2}{6}(k - k^2)(2 - k)$$

$$\text{or } R_1^* = Pl^2 \times \frac{1}{6}(2k - 3k^2 + k^3)$$

$$R_2^* = \frac{Pl^2}{2}(k - k^2) \times \frac{l}{3}(1 + k)/l$$

$$= \frac{Pl^2}{6}(k - k^2)(1 + k)$$

PART 2

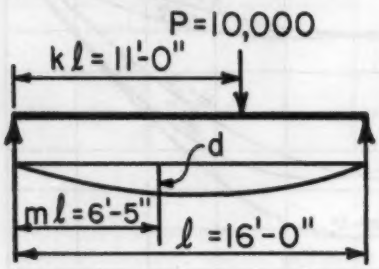

FIGURE 13—Example.

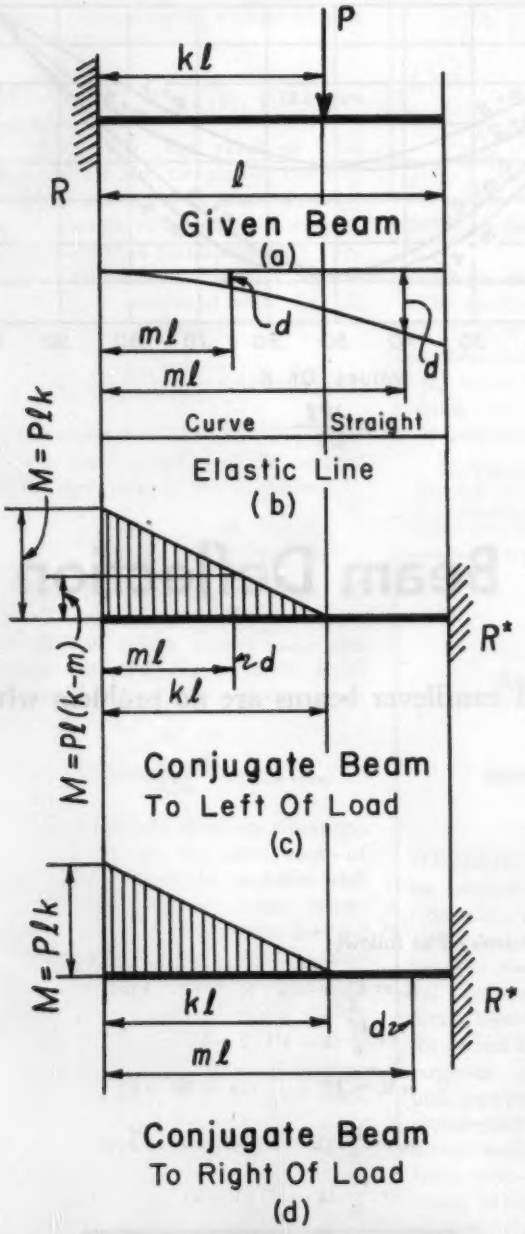

FIGURE 14—Given and Conjugate beam under concentrated load on cantilever beam.

$$\text{or } \overset{*}{R_3} = Pl^2 \times \frac{1}{6}(k - k^3)$$

Multiplying the coefficients of Pl^2 in the above equations by 144; thus reducing them to inch units, and also representing these expressions by L_1 and L_2 respectively:

$$\text{Then } L_1 = \frac{144}{6}(2k - 3k^2 + k^3)$$

$$L_2 = \frac{144}{6}(k - k^3)$$

$$\text{Also } \overset{*}{R_1} = L_1 Pl^2$$

$$\overset{*}{R_3} = L_2 Pl^2$$

$$\overset{*}{M_1} = \overset{*}{R_1} ml - Plm\,(1-k)\,ml/2 \times \frac{1}{3}ml$$

$$= \frac{Pl^3}{6}(2k - 3k^3 + k^3)\,m - \frac{Pl^3}{6}(1-k)\,m^3$$

$$\overset{*}{M_1} = Pl^3 \frac{1}{6}[(2k - 3k^2 + k^3)\,m - (1-k)\,m^3]$$

. . . . . Equation 11

The moment to the right of the load (Figure 11c) is determined as follows:

$$\overset{*}{M_2} = \overset{*}{R_3} l\,(1-m) - Plk\,(1-m) \times l\,(1-m)/2 \times \frac{1}{3} l\,(1-m)$$

$$= \frac{Pl^3}{6}(k - k^3)\,(1-m) - \frac{Pl^3}{6} \times k\,(1-m)^3$$

$$\overset{*}{M_2} = Pl^3 \frac{1}{6}\left[(k - k^3)\,(1-m) - k\,(1-m)^3\right]$$

. . . . . Equation 12

Multiplying the coefficients of Pl^3 in Equation 11 and 12 by the cube of 12; thus reducing to inch units, and letting "J" denote the following:

To the left of the load— $J = \frac{1728}{6} \times [(2k - 3k^2 + k^3)\,m - (1-k)\,m^3]$

To the right of the load— $J = \frac{1728}{6} \times [(k - k^3)\,(1-m) - k\,(1-m)^3]$

$$\text{Then } \overset{*}{M} = JPl^3$$

$$\text{and } d = \frac{JPl^3}{EI} \quad . \quad . \quad . \quad . \quad \text{Equation 13}$$

Values of "J" have been computed for values of k and

TABLE 5

Table of Values of Deflection Coefficients for Concentrated Load on Simple Beam

TABLE OF VALUES OF J

m \ k	.1	.2	.3	.4	.5	.6	.7	.8	.9
.1	4.67	8.06	10.08	10.89	10.66	9.56	7.78	5.47	2.82
.2	8.06	14.75	18.95	20.73	20.45	18.43	15.03	10.6	5.47
.3	10.08	18.95	25.4	28.5	28.5	25.9	21.25	15.03	7.78
.4	10.89	20.73	28.5	33.18	33.99	31.33	25.9	18.43	9.56
.5	10.66	20.45	28.5	33.99	36.0	33.99	28.5	20.45	10.66
.6	9.56	18.43	25.9	31.33	33.99	33.18	28.5	20.73	10.89
.7	7.78	15.03	21.25	25.9	28.5	28.5	25.4	18.95	10.08
.8	5.47	10.6	15.03	18.43	20.45	20.73	18.95	14.75	8.06
.9	2.82	5.47	7.78	9.56	10.66	10.89	10.08	8.06	4.67

Note: Values of "J" are in inch units. Divide by 1728 for foot units. Thus, when k = .5 Σ m = .5, $J = \frac{36}{1728} = \frac{1}{48}$ or $d = \frac{1}{48}\frac{Pl^3}{EJ}$

m ranging from 0 to 1.0, and are found in Table 5 and are shown on the graph in Figure 12.

Example: Determine the deflection 6′-5″ from the left support for a load located 11′-0″ from the left support, l = 16′-0″, E = 30,000,000, and I = 85. (Figure 13.)

$$k = \frac{11'\text{-}0''}{16'\text{-}0''} = .69,\ m = \frac{6'\text{-}5''}{16'\text{-}0''} = .4$$

Then from Figure 12, J = 26.5 and $d = \frac{JPl^3}{EI}$

$$d = \frac{26.5 \times 10{,}000 \times (16'\text{-}0'')^3}{30{,}000{,}000 \times 85} = .424''$$

Deflection of Cantilever Beam—To determine the deflection of a cantilever beam when a concentrated load is applied at any point over the span, find the moments first, for the given beam. If the reaction is P, the bending moment at the support is Plk.

On a cantilever beam, the support for the conjugate beam is placed on the opposite end to that of a given beam, so that the moment and shear of the conjugate beam are zero at the same point that the deflection and slope are zero in the given beam. Also, where the moment and shear are a maximum in the conjugate beam, the deflection and slope are a maximum in the given beam.

The conjugate bending moment at any point to the left of the load between 0 and kl from the left end (See Figure 14c.) is:

$$d = \frac{M^*}{EI},\ \Theta = \frac{R^*}{EI} = \frac{Pl^2k^2}{2EI}$$

$$M^* = [Plk - Pl\,(k - m)]\frac{ml}{2} \times \frac{2}{3}\,ml + Pl\,(k - m)\,ml \cdot \frac{ml}{2}$$

$$\text{or } M^* = Pl^3\left[\frac{m^3}{3} + \frac{m^3}{2}(k - m)\right] \quad \text{. . . . . Equation 14}$$

The conjugate bending moment to the right of the load is:

M* at any point to the right of the load between kl and l. See Figure 14d.

$$M^* = Plk \times \frac{kl}{2}\left(ml - \frac{kl}{3}\right)$$

$$\text{or } M^* = Pl^3 \cdot \frac{k^2}{2}\left(m - \frac{k}{3}\right) \quad \text{. . . Equation 15}$$

Let Q represent the coefficients of Pl^3 in Equations 4 and 5. Also, multiply the equation by 1728 which reduces the equation to inch units.

$$Q = 1728\left[\frac{m^3}{3} + \frac{m^2}{2}(k - m)\right] \text{ To the left of the load}$$

$$Q = 1728\left[\frac{k^2}{2}\left(m - \frac{k}{3}\right)\right] \text{ To the right of the load}$$

$$\text{Then } d = \frac{QPl^3}{EI} \quad \text{. . . Equation 16}$$

Values of Q are calculated in Table 6 for the value of k and m varying from 0 to 1.0. These values are also plotted on Figure 15. The curves are influence lines for the deflection as the load moves over the span.

Example: Determine the deflection of a cantilever beam 16′-0″ from the support for a load of 10,000 pounds, located 14′-0″ from the support. E = 30,000,000, I = 724.4. See Figure 16.

$$k = \frac{14'\text{-}0''}{20'\text{-}0''} = .7,\ m = \frac{16'\text{-}0''}{20'\text{-}0''} = .8$$

From Table 6: Q = 240 $d = \frac{QPl^3}{EI}$

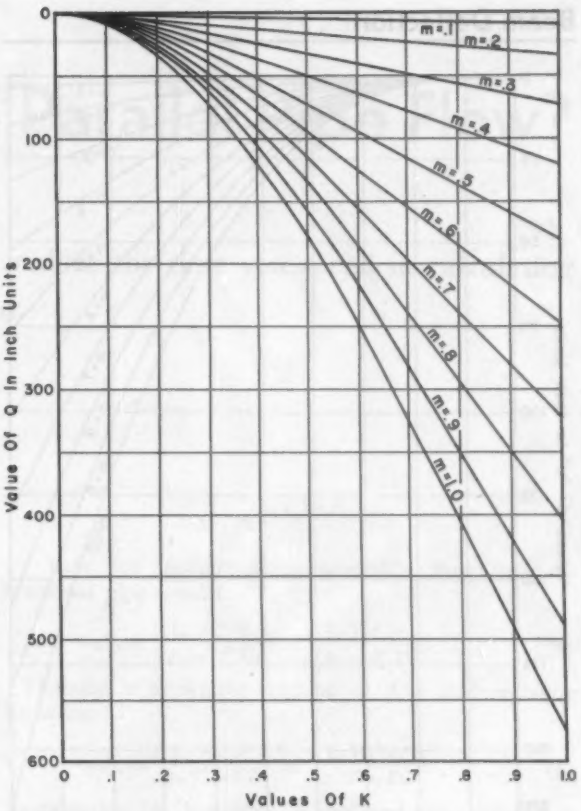

FIGURE 15—Deflection coefficients for concentrated load on cantilever beam.

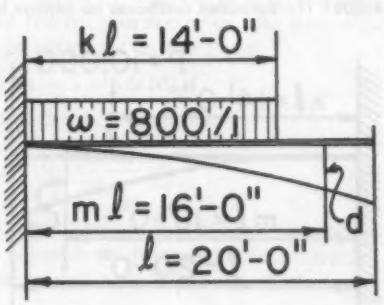

FIGURE 16—Example.

TABLE 6

Table Values of Deflection Coefficients for Concentrated Load on Cantilever Beam

TABLE OF VALUES OF Q

m \ k	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
.1	.576	1.44	2.30	3.16	4.03	4.89	5.76	6.62	7.48	8.35
.2	1.44	4.67	8.13	11.59	15.04	18.5	21.95	25.41	28.87	32.32
.3	2.30	8.13	15.55	23.33	31.11	38.89	46.67	54.45	62.23	70.01
.4	3.16	11.59	23.33	36.81	50.63	64.45	78.27	92.09	105.91	119.73
.5	4.03	15.04	31.11	50.63	72.06	93.66	115.26	136.86	158.46	180.06
.6	4.89	18.5	38.89	64.45	93.66	124.42	155.52	186.62	217.72	248.82
.7	5.76	21.95	46.67	78.27	115.26	155.52	197.51	239.85	282.19	324.53
.8	6.62	25.41	54.45	92.09	136.86	186.62	239.85	294.97	350.27	405.57
.9	7.48	28.87	62.23	105.91	158.46	217.72	282.19	350.27	419.90	489.88
1.0	8.35	32.32	70.01	119.73	180.06	248.82	324.53	405.57	489.88	576.0

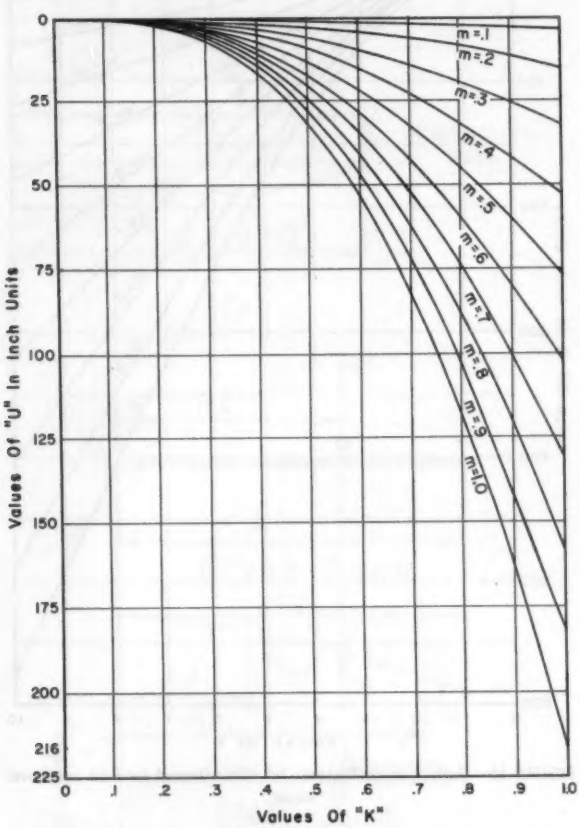

FIGURE 17—Deflection coefficient for uniform load on cantilever beam.

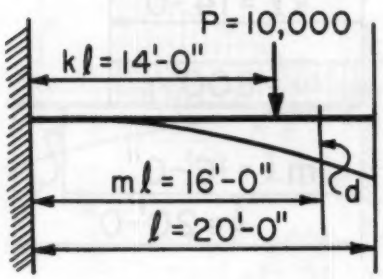

FIGURE 18—Example.

$$\text{Therefore, } d = \frac{240 \times 10{,}000 \times 20^3}{30{,}000{,}000 \times 724.4} = .882''$$

To determine the deflection of a cantilever beam reacting under a uniform load, the derivation is as follows:

The given beam is: $M = \frac{w}{2}(kl - x)^2$

Case 1—The deflection at any point under load.

Conjugate beam:

Let ml represent the point of deflection under load. The differential moment for the conjugate beam is:

$$d\overset{*}{M} = M dx \cdot (ml - x)$$

$$= \frac{w}{2}(kl - x)^2 (ml - x)$$

$$\overset{*}{M} = \frac{w}{2}\int_0^{ml} k^2m^2l^2 - (2kml^2 + k^2l^2)x + (ml + 2kl)x^2 - x^3$$

Integrating:

$$\overset{*}{M} = \frac{w}{2}\Big[k^2m^2l^2x - (2kml^2 + k^2l^2)\frac{x^2}{2} + (ml + 2kl)\frac{x^3}{3} - \frac{x^4}{4}\Big]_0^{ml}$$

Substituting ml for x and factoring, the following result is obtained.

$$\overset{*}{M} = \frac{wl^4}{8}\Big[2k^2m^2 - \frac{4}{3}km^3 + \frac{m^4}{3}\Big] \quad \text{. . . Equation 17}$$

Case 2—Deflection at any point beyond the end of the load. For this case, let ml represent the point of deflection beyond the load. Using the same integral as above, and substituting for this case between the limits of kl and 0.

$$\overset{*}{M} = \Big[k^2m^2l^2x - (2kml^2 + k^2l^2)\frac{x^2}{2} + (ml + 2kl)\frac{x^3}{3} - \frac{x^4}{4}\Big]_0^{kl}$$

Substituting kl for x and factoring, the following result is obtained.

$$\overset{*}{M} = \frac{wl^4}{6}k^3\Big[m - \frac{k}{4}\Big] \quad \text{. . . Equation 18}$$

Letting "U" represent the coefficients of wl^4 in Equations 17 and 18, and also multiplying by the cube of 12 (1728) to reduce to inch units:

$$U = \frac{1}{8}\Big[2k^2m^2 - \frac{4}{3}km^3 + \frac{m^4}{3}\Big]1728 \quad \text{Under load}$$

$$U = \frac{1}{6}k^3\Big[m - \frac{k}{4}\Big]1728 \quad \text{Beyond end of load}$$

$$\text{Then } \overset{*}{M} = Uwl^4$$

$$\text{And Deflection } d = \frac{Uwl^4}{EI}$$

Values of U are found in Table 7 and are also plotted on Figure 17 for values of k varying from 0 to 1.0.

TABLE 7

Table Values of Deflection Coefficients for Uniform Load on Cantilever Beam

TABLE OF VALUES OF U

m \ k	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
.1	.022	.121	.309	.584	.942	1.39	1.92	2.54	3.24	4.04
.2	.050	.346	.973	1.95	3.28	4.95	6.95	9.34	12.0	15.1
.3	.079	.576	1.75	3.78	6.42	9.92	14.2	19.2	25.1	31.7
.4	.107	.807	2.53	5.53	9.92	15.7	22.8	31.3	41.3	52.5
.5	.137	1.04	3.31	7.38	13.5	21.8	32.2	44.8	60.0	76.5
.6	.166	.127	4.08	9.50	17.1	27.9	42.0	59.1	79.4	103.0
.7	.194	1.50	4.85	11.0	20.7	34.1	51.8	73.5	99.6	130.5
.8	.223	1.73	5.65	12.9	24.1	40.5	61.6	88.5	118.5	158.0
.9	.254	1.96	6.43	14.7	27.9	46.7	71.5	103.2	141.5	186.5
1.0	.281	2.18	7.18	16.6	31.5	52.8	81.6	117.8	162.6	216.0

Example: Determine the deflection at a point 16′-0″ from the support loaded as in Figure 18. E = 30,000,000 and 1 = 724.

$$k = \frac{14'\text{-}0''}{20'\text{-}0''} = .7, \qquad m = \frac{16'\text{-}0''}{20'\text{-}0''} = .8$$

From Table 7 or Figure 17, k = .7, m = .8, U = 61.6

$$d = \frac{61.6 \times 800 \times 20^4}{30{,}000{,}000 \times 724} = .373''$$

Part 3 will appear in an early issue of PETROLEUM REFINER

ACKNOWLEDGMENT

From a privately circulated book by Charles H. Fork entitled "Structural Design Data on Deflection of Beams" upon which the author holds the copyright.

##

Having Trouble With Parallel Pipe Flow?

Here's a method that will really reduce the time you spend in calculating the percent of flow in parallel piping systems.

Albert J. Paquette
Baton Rouge, La.

THIS SIMPLIFIED method of determining the fractional flow in a two-branch parallel pipe system is based on expressing the friction factor as an equation involving both the Reynolds number and the relative roughness ratio, ε/D; thus permitting the direct evaluation of flow in each branch.

One of the problems which normally requires a time-consuming trial-and-error solution by the design engineer is the one for the evaluation of fluid flow in parallel piping systems.

After writing the general pressure drop equation which relates the isothermal-incompressible fluid flow in a two-branched parallel piping system

$$-\Delta P_f = \frac{f_1 L_1 W_1^2 16 \rho_1}{2g_c \rho_1^2 \pi^2 D_1^5} = \frac{f_2 L_2 W_2^2 16 \rho_2}{2g_c \rho_2^2 \pi^2 D_2^5} \quad (1)$$

the following procedure would normally be used to evaluate the flow in each branch:

1. Assume a flow in Branch 1.
2. Calculate the Reynolds number for each branch.
3. From the pipe internal diameters and materials, determine the relative roughness ratio.[1]
4. Using Moody's[1] friction factor plot which relates the Reynolds number and the relative roughness ratio, determine the friction factors for each branch.
5. Substituting these numbers into Equation (1) and solve for ΔP_f.

If the correct weight flow was assumed in 1 above, the two branches will have equal pressure drops. If the pressure drops are not equal, a new value of flow is assumed and the above steps repeated until the two pressure drops are equal.

Under certain flow conditions simplifications can be made to Equation (1) which reduces it to a direct solution. If the flows in both branches are fully turbulent, then the friction factors for each branch are constant and Equation (1) reduces to a straightforward solution for the flow in each branch given the branch lengths and diamaters. Another simplification would be the assumption of smooth pipe for both branches; thereby allowing the use of an equation for the friction factors.

Developing Equation and Chart—Starting with the general equation for pressure drop in circular conduits

$$-\Delta P_f = \frac{f \rho L V^2}{2g_c D} \quad (2)$$

we have for isothermal-incompressible flow in two-branched pipe system

$$-\Delta P_f = \frac{f_1 L_1 W_1^2 16 \rho_1}{2g_c \rho_1^2 \pi^2 D_1^5} = \frac{f_2 L_2 W_2^2 16 \rho_2}{2g_c \rho_2^2 \pi^2 D_2^5} \quad (3)$$

Defining σ as weight fraction of flow and reducing Equation (3)

$$-\Delta P_f = \frac{f_1 L_1 W_T^2 \sigma_1^2 8}{g_c \pi^2 \rho_1 D_1^5} = \frac{f_2 L_2 W_T^2 \sigma_2^2 8}{g_c \pi^2 \rho_2 D_2^5} \quad (4)$$

As Equation (4) is written, a trial and error solution is required to find σ_1 and σ_2 due to the fact that the friction factors themselves are functions of σ_1 and σ_2. Fortunately this problem can be solved by the use of Coulson and Richardson's[2] plot of the friction factor vs. the Reynolds number which can be expressed in the form.

$$ln\, N_{Re} = a + b\, ln\, N^2_{Re}\, f \quad (5)$$

for turbulent flow and can be reduced to

$$f = \frac{N_{Re}^{\left(\frac{1-2b}{b}\right)}}{e^{(a/b)}} \quad (6)$$

where a and b are functions of the relative roughness ratio, ε/D. Figure 1 has been prepared which enables the determination of a and b as functions of the relative roughness ratio.

Substituting Equation (6) into Equation (4) and writing out the terms of the Reynolds number

$$-\Delta P_f = \frac{\left[\frac{\phi W_T \sigma_1}{D_1 Z_1}\right]^{\left(\frac{1-2b}{b}\right)_1} L_1 W_T^2 \sigma_1^2 8}{g_c \rho_1 \pi^2 D_1^5 e^{(a/b)_1}} = \frac{\left[\frac{\phi W_T \sigma_2}{D_2 Z_2}\right]^{\left(\frac{1-2b}{b}\right)_2} L_2 W_T^2 \sigma_2^2 8}{g_c \rho_2 \pi^2 D_2^5 e^{(a/b)_2}} \quad (7)$$

Example 1: Determine the fraction fluid flowing in the following parallel pipe system: Branch 1, Cast Iron, nominal diameter of 2 in. and a length of 10 ft. Branch 2, Drawn Tubing, D_2, nominal diameter of 3 in. and a length, L_2, of 100 ft.

Solution—From Figure 1 it is seen that the assumption of equal ε/D ratios for each branch cannot be used here, so read from Figure 1 the following values for use in Equation (7)

Branch 1 a=1.39
b=0.475
a/b=3.2

Having Trouble with Parallel Pipe Flow? . .

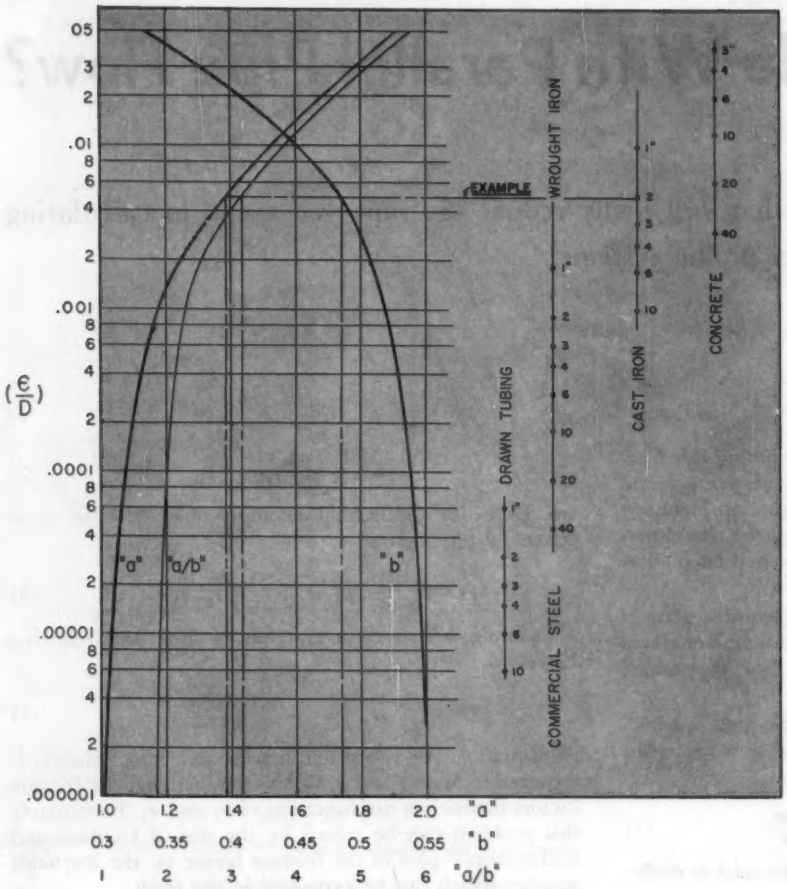

FIGURE 1—If flow is turbulent for both branches, use this graph to obtain the needed exponents for solution of Equation (7).

About the Author

A. J. PAQUETTE spent two years in cooperative employment with the Detroit Edison Co., one year with the U. S. Naval Ordnance Test Station at China Lake, Calif., and worked part-time in the Engineering Research Institute of the University of Michigan. He received his M.S. degree from Michigan in 1955 and since then has worked in the field of petrochemicals.

Branch 2 $a=1.05$
$b=0.540$
$a/b=1.90$

Reducing and rearranging Equation (7) to a more convenient form

$$\frac{e^{\left(\frac{a}{b}\right)_2}\ D_2^{\left(\frac{3b+1}{b}\right)_2}\ L_1\,[\phi W_T]^{\left(\frac{1-2b}{b}\right)_1}}{e^{\left(\frac{a}{b}\right)_1}\ D_1^{\left(\frac{3b+1}{b}\right)_1}\ L_2\,[\phi W_T]^{\left(\frac{1-2b}{b}\right)_2}} = \frac{(1-\sigma_1)^{\left(\frac{1}{b}\right)_2}}{\sigma_1^{\left(\frac{1}{b}\right)_1}}$$

Substituting the above values for a, b, and a/b in the above equation with $W_T = 100$ #/sec.

$$\frac{e^{1.90}\left(\frac{3}{12}\right)^{4.85}\ 10\,[189000]^{0.105}}{e^{3.2}\left(\frac{2}{12}\right)^{5.1}\ 100\,[189000]^{-0.148}} = \frac{(1-\sigma_1)^{1.85}}{\sigma_1^{2.11}}$$

Solving for σ_1 it is found that $\sigma_1=0.30$ and $\sigma_2=1-\sigma_1=0.70$.

Example 2: Determine the fraction fluid flowing in each of the parallel pipe branches for the following system: Branch 1, length (L_1) equals 100 feet with a nominal diameter (D_1) of 8 inches. Branch 2, length equals 10 feet of 2½ inch nominal diameter pipe. Both branches can be considered smooth pipe.

Solution—Since both branches are smooth pipe, read from Figure 1, b = 0.55. Putting equation (7) in a more convenient form we have

$$\left(\frac{\sigma_1}{1-\sigma_1}\right)^{\frac{1}{b}} = \left(\frac{D_1}{D_2}\right)^{\frac{1+3b}{b}}\left(\frac{L_2}{L_1}\right)$$

which when substituting the above values and solving for σ_1 and σ_2 yields

$$\left(\frac{\sigma_1}{1-\sigma_1}\right) = \left(\frac{8}{2.5}\right)^{(1+3b)}\left(\frac{10}{100}\right)^{b}$$

and $\sigma_1 = 0.86$ and $1-\sigma_1 = \sigma_2 = 0.14$

SYMBOLS

ΔP_f = pressure drop, lbs./sq. ft.
ρ = fluid density, lbs./cu. ft.
L = length, ft.
V = velocity, ft./sec.
g_c = conversion factor
D = pipe internal diameter, ft.
W = weight flow, lbs./sec.
σ = weight fraction flow.
N_{Re} = Reynolds Number = $\left[\frac{\phi W}{DZ}\right]$
f = friction factor
a = function of ϵ/D
b = function of ϵ/D
ϵ/D = relative roughness ratio
Z = viscosity, cps
ϕ = constant = 1890

Subscripts

1 = refers to Branch 1
2 = refers to Branch 2
T = total

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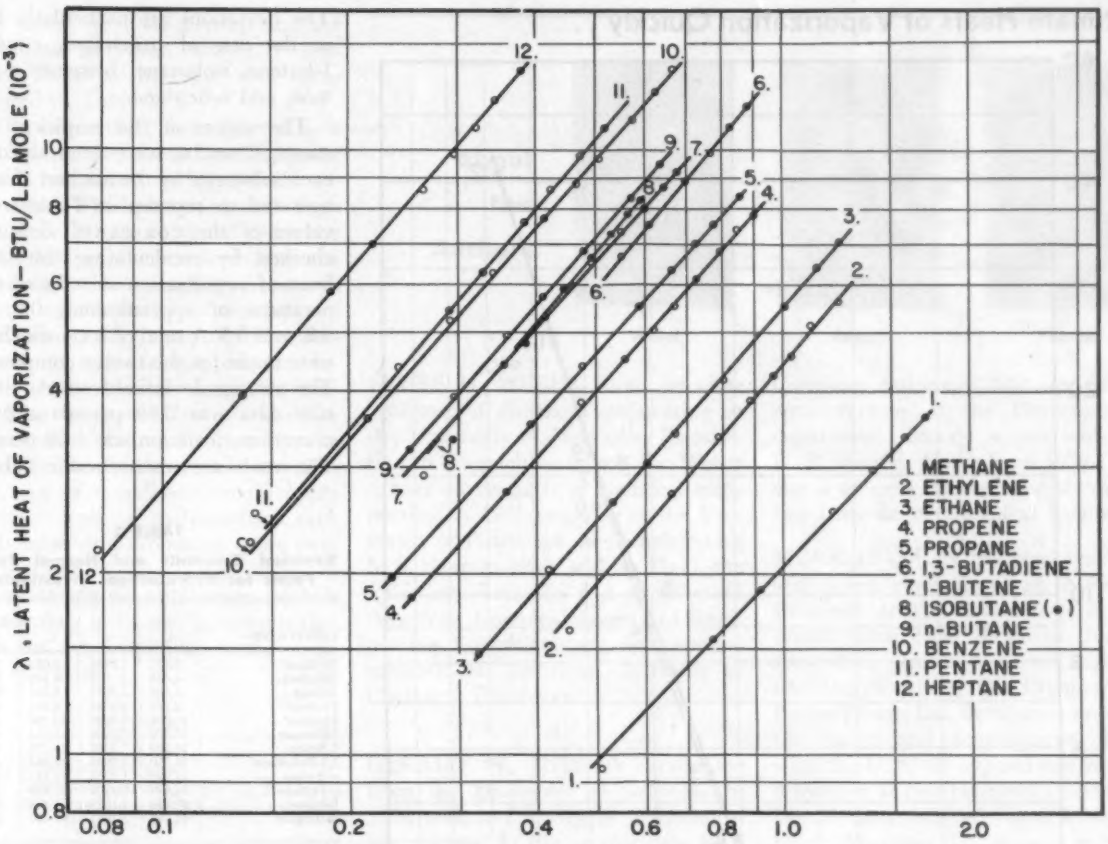

FIGURE 1—Molal latent heat of vaporization versus density difference.

Here's a new way to estimate . . .

Heats of Vaporization Quickly

No need to find the slope of vapor pressure versus temperature curves; simply use the liquid density and constants derived in this article to find heats of vaporization.

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Merk Hobson, Continental Oil Company
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THE CALCULATION of the latent heat of vaporization of a pure substance by the thermodynamically rigorous Clapeyron equation involves a knowledge of the pressure-volume-temperature relationship along the phase boundary, including the slope of the vapor pressure versus temperature curve. Since the accurate determination of the value of the slope term, dP/dT, is difficult even when the necessary data are available, the development of a reliable method to predict latent heats of vaporization which does not require this determination is very desirable. Recently, Magaril[5] has suggested a simple empirical relationship

$$\lambda = C(d_o - d)^n \qquad (1)$$

where λ = molal latent heat of vaporization, Btu/lb. mole
C and n = empirical constants
d_o = molal liquid density, pound moles per cubic foot
d = molal vapor density, pound moles per cubic foot

which is based on the density difference.

Estimate Heats of Vaporization Quickly . . .

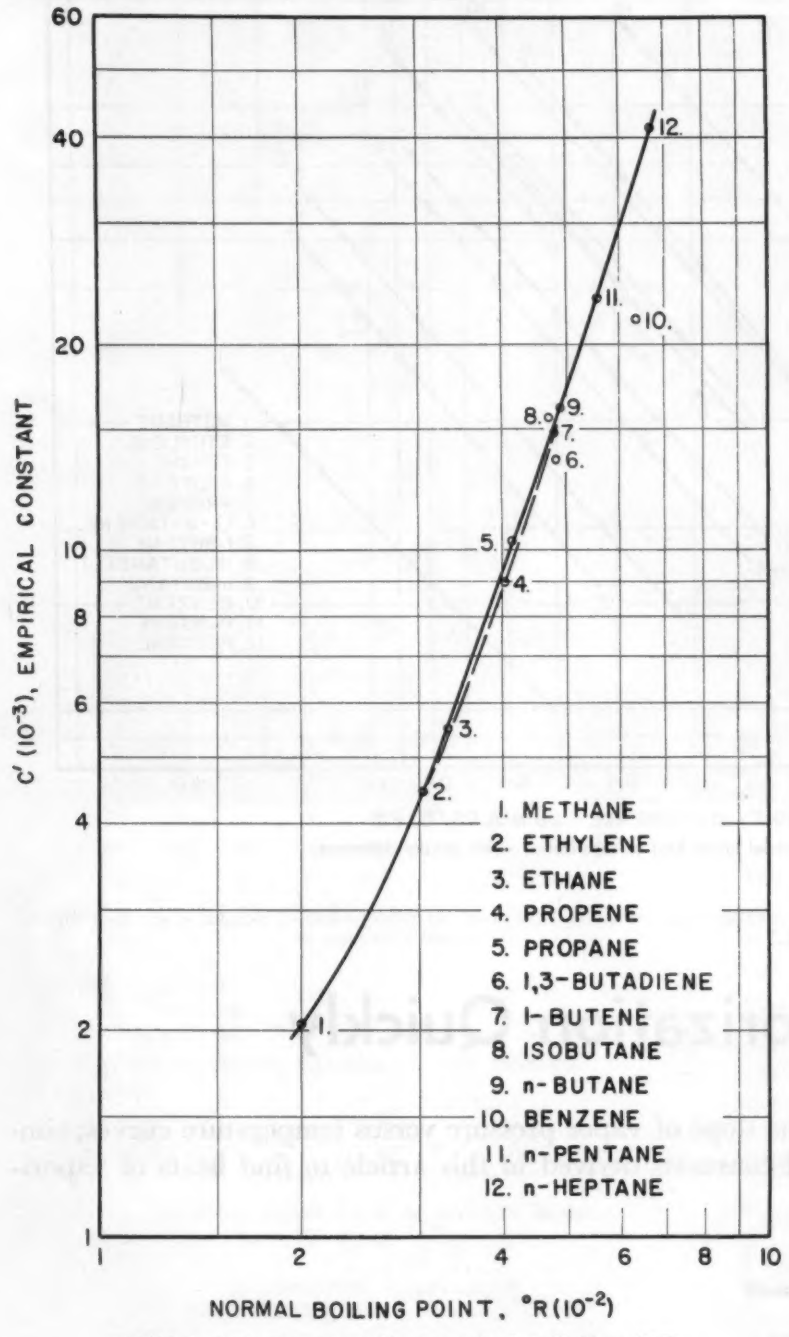

FIGURE 2—Empirical constant, C', of equation $\lambda = C' (d_o - d)^{1.165}$.

The accuracy of Magaril's relationship was tested against latent heat of vaporization data reported in the literature for twelve hydrocarbons; namely methane,[6] ethane,[1] propane,[11] n-butane,[9] n-pentane,[2] n-heptane,[12] isobutane,[10] ethylene,[14] propene,[3] 1-butene,[13] 1,3-butadiene,[7] and benzene.[8] As qualitative check on Equation 1, the molal latent heats of vaporization were plotted against the density difference on logarithmic coordinates. This plot is included as Figure 1. It will be noted from the plot that the deviations from the straight line only become large as the density difference becomes small; i.e., as the critical point is approached. The deviations are particularly large in the case of methane, ethylene, 1-butene, isobutane, benzene, n-pentane, and n-heptane.

The values of the empirical constants, C and n, were determined for each substance by the method of averages and are reported in Table 1. The values of the constants were then checked by recalculating the latent heats of vaporization at reduced temperatures of approximately 0.6, 0.7, 0.8, and 0.9. A total of forty-six checks were made for the twelve compounds. The average deviation from the literature data was 0.49 percent and the maximum deviation was 1.62 percent. The results are summarized in Table 2.

TABLE 1

Empirical Constants and Normal Boiling Points for Hydrocarbons Investigated

COMPOUND	C	n	C'	N.B.P. °R.*
Methane	2,073	1.0684	2,034	200.9
Ethylene	4,445	1.1817	4,440	304.9
Ethane	5,504	1.1645	5,504	332.2
Propene	8,858	1.1386	8,986	405.7
Propane	10,089	1.1229	10,309	415.8
Isobutane	15,570	1.1909	15,654	470.5
1-Butene	14,260	1.1122	14,779	480.2
1,3-Butadiene	13,710	1.2003	13,553	483.7
n-Butane	15,900	1.1553	16,121	490.7
n-Pentane	24,580	1.2205	23,285	556.6
Benzene	21,700	1.1589	21,809	635.8
n-Heptane	43,140	1.1985	41,267	668.7

* Absolute temperature, degrees Rankine.

TABLE 2

Summary of Results

Compound	Ranges of T_R	No. of Checks	PERCENT DEVIATION $\lambda = C(d_o - d)^n$ Ave.	Max.	$\lambda = C'(d_o - d)^{1.165}$ Ave.	Max.
Methane	0.64–0.93	4	0.34	0.50	1.49	2.37
Ethylene	0.63–0.90	4	0.71	1.45	0.60	1.74
Ethane	0.58–0.87	4	0.82	1.22	0.83	1.24
Propene	0.62–0.91	4	0.48	0.90	0.69	1.01
Propane	0.57–0.93	4	0.24	0.54	1.13	1.73
Isobutane	0.72–0.88	3	0.13	0.17	0.33	0.52
1-Butene	0.66–0.90	4	0.50	0.68	1.23	1.86
1,3-Butadiene	0.60–0.86	4	0.09	0.17	0.41	0.89
n-Butane	0.65–0.91	4	0.25	0.33	0.27	0.51
n-Pentane	0.67–0.90	4	0.39	0.80	1.02	1.39
Benzene	0.59–0.91	4	1.02	1.62	1.03	1.78
n-Heptane	0.69–0.90	3	0.95	1.49	1.15	1.74
Total		46				
			Ave. Dev. = 0.49%		Ave. Dev. = 0.85%	
			Max. Dev. = 1.62%		Max. Dev. = 2.37%	

It was noted that the values of n for the 12 compounds were approximately constant. Selecting an average value of n as 1.165, a second value of the other empirical constant was calculated and labelled C'. The ability of the new values to reproduce the literature data was checked in the same manner as was used for the original constants. For the 46 data checked the average deviation from the litera-

ture values was 0.85 percent and the maximum deviation was 2.37 percent. These results are also summarized in Table 2.

The values of C' were plotted as a function of the normal boiling point of the compound on logarithmic coordinates. This plot is included as Figure 2. It can be noted from the plot that the points representing the six straight chain paraffin compounds form a smooth curve. While data are available on only three olefinic compounds, it appears that the correlation for the olefinic series, as indicated by the dashed line, would differ slightly from that of the paraffins. In order to reach the conclusion that this type of correlation would apply to other types of hydrocarbons such as diolefins and aromatics, more data are required.

An interesting application of this relationship is its use in conjunction with the compressibility factor equation of a state

$$\frac{P}{d} = zRT \qquad (2)$$

where P = pressure, psia
T = absolute temperature, °R
R = gas law constant, 10.73 psia-ft³/lb. mole-°R
z = compressibility factor

It can be shown that:

$$(d_o - d) = \frac{P}{RT}\left(\frac{1}{z_l} - \frac{1}{z_v}\right) \qquad (3)$$

where z_l = Compressibility factor for the liquid phase
z_v = compressibility factor for the vapor

The compressibility factors, z_l and z_v, can be evaluated from a plot of z versus reduced pressure with various values of the critical compressibility factor as additional parameters.[4] Combining Equations 1 and 3 gives:

$$\lambda = C\left[\frac{P}{RT}\left(\frac{1}{z_l} - \frac{1}{z_v}\right)\right]^n \qquad (4)$$

With this relationship it is possible to evaluate the latent heat of vaporization knowing only the temperature, pressure, and critical properties of the properties of the particular hydrocarbon.

A simplified version of Equation 1 can be obtained by eliminating the vapor density

$$\lambda = C\,(d_o)^n \qquad (5)$$

This simplification is similar to the assumption made in the development of the Clausius-Clapeyron equation that the liquid volume is insignificant when compared to the vapor volume. Values of the latent heat of vaporization were calculated from Equation 5 for the saturated hydrocarbons. Below a T_R (reduced temperature) of 0.6, the maximum deviation from the literature values resulting from the use of this simplified equation was less than 1 percent. At a T_R of 0.7, where the vapor density becomes more significant, the results predicted by Equation 5 showed a maximum deviation of 4 percent and at higher T_R's, the percentage error increased rapidly, as might be expected.

In summation, it has been shown that for the hydrocarbons investigated, the latent heat of vaporization can be predicted with a high degree of accuracy by Equation 1, which does not require the evaluation of the slope of the vapor pressure versus temperature curve. It has also been shown that for these hydrocarbons a common value of the empirical constant, n, can be used without appreciably decreasing the accuracy of the results obtained. It appears that the values of the other empirical constant, C', can be correlated with the normal boiling points of the compounds in a particular hydrocarbon series. It has also been shown that it is possible to ignore the vapor density term at T_R's of 0.6 or below and still obtain accurate results.

About the Authors

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JAMES H. WEBER is an associate professor of chemical engineering at the University of Nebraska. In addition to his teaching duties, Dr. Weber carries on research in chemical engineering. A 1941 graduate of the University of Pittsburgh, he completed his M.S. there in 1947, and his Ph.D. the following year. He is a member of American Chemical Society of Engineering Education, and an associate member of American Institute of Chemical Engineers.

•

GERALD W. INBODY graduated from the University of Nebraska in 1956 with a B.S. degree in chemical engineering. At the present time he is a process engineer for Continental Oil Company, Baltimore, Md., on an orientation tour of the Petrochemical department. Inbody served with the U. S. Army in Alaska from 1950-1952, and is an associate member of American Institute of Chemical Engineers.

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MERK HOBSON has been teaching and doing research as an Associate Professor at the University of Nebraska since 1950. Prior to this he spent three years as a process engineer for Esso Standard Oil Company in Baton Rouge, La., three years as product design and development officer with the U. S. Army, and one year as a lecturer at Northwestern University. Dr. Hobson received his B.S. degree from Wisconsin University, and his M.S. and Ph.D. from Northwestern.

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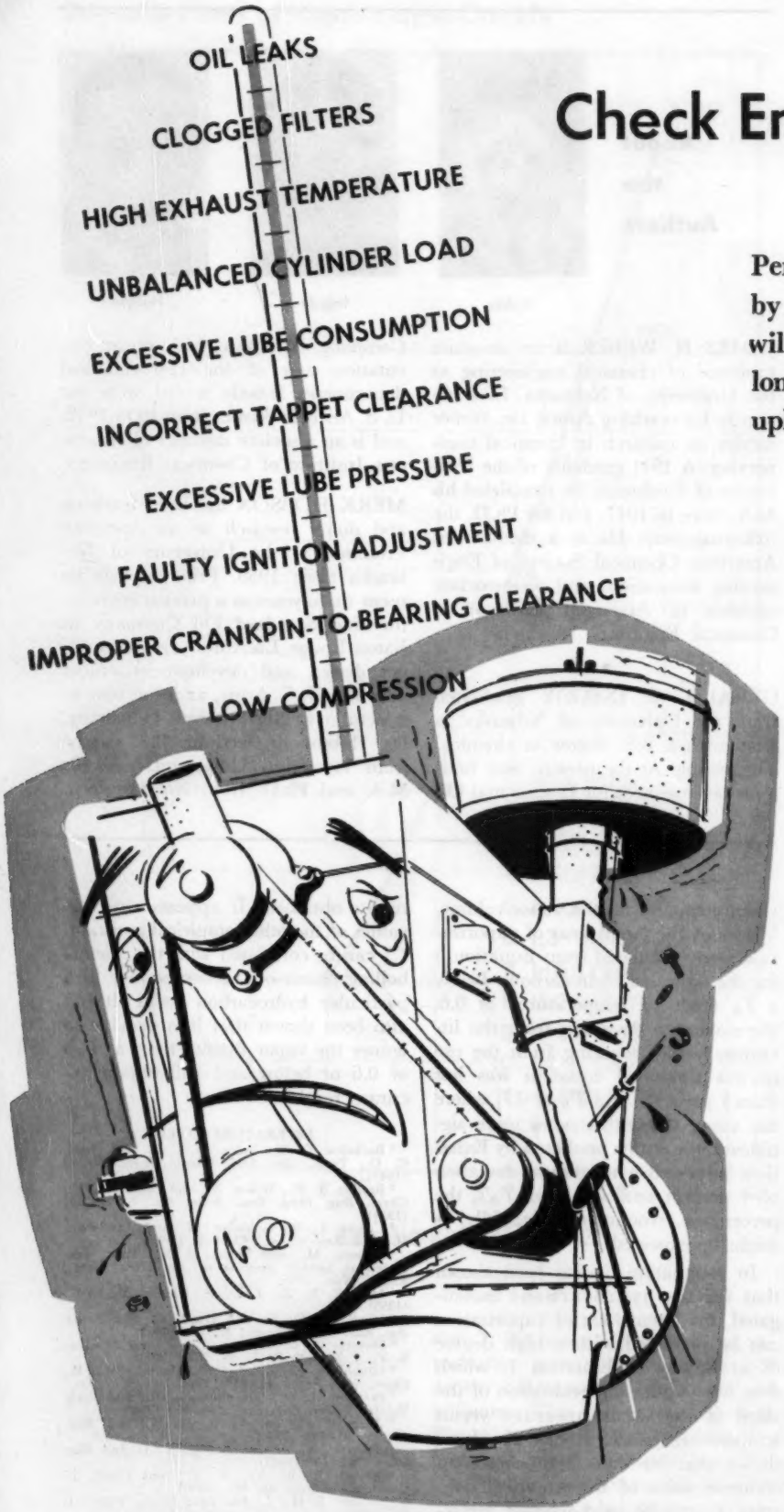
Check Engine Trouble

Periodic inspections, backed up by sound maintenance practices, will keep your engine on the line longer and reduce the cost of upkeep.

J. W. Kehres
The Cooper-Bessemer Corporation
Mount Vernon, Ohio



"Barometers" for Inspection that Indicate Trouble Ahead

ENGINES CAN be kept on the line longer and will require less maintenance if periodic inspections are made and followed up with the required preventive maintenance.

Constant checks must be made on the engine to detect any change in its condition. These checks can be called "barometers" of engine condition and can indicate trouble ahead.

In evaluating preventive maintenance, it must be noted that it prevents serious breakdowns of the engine. Abnormal wear can be measured and minor derangements detected so that necessary repairs can be made before serious damage can result. Even if the unit can be shut down immediately, adjustments cannot be made to permit temporary safe operation.

Normal wear of the engine can be repaired quickly and conveniently by relying solely on periodic inspections. But they will not guard against unforeseen mishaps in engine operation that occur every day. Maximum availability for the least labor and spare parts cost is another advantage of preventive maintenance.

Here are some of the "barometers" that indicate engine condition.

Ignition Adjustment—This is one of the most important functions in the care of engines. Proper ignition adjustment not only affects engine operation but also some of the impor-

Before it Starts

tant "barometers" of engine condition. If ignition timing is retarded, high exhaust temperature and high fuel consumption will result. Advanced timing will produce high peak pressures. Non-uniform timing among cylinders will produce false balance as the cylinders with retarded timing will be overloaded and those with advanced timing will be underloaded. After placing the ignition system in good condition, determine how long it will operate free of trouble. Make the period between inspections somewhat shorter than this to insure good operation.

Balanced Cylinder Load—Another important periodic inspection is the balancing of the load among cylinders. Balancing by peak pressures has proved the most reliable method. The ignition should be in good condition before attempting to balance the load. An uneven load condition will result in some cylinders operating in excess of design rating and others under design rating.

In the first condition, rings and pistons will experience high rates of wear. High peak pressures can cause cylinder head and piston failures. In the second condition, poor combustion and excessive lubrication can cause carbon formation that will stick rings and valves, foul spark plugs and clog cylinder ports. Thus, a unit might have to be shut down to repair one or two cylinders and pistons while the general condition of all cylinders is good.

Tappet Clearance—The tappet clearance should be adjusted to proper value before balancing the load on two-cycle engines. Even though the load can be balanced with uneven tappet clearances, the cylinders with high tappet clearance will have shorter gas injection duration which may cause poor mixture and rough combustion. On four-cycle engines and some two-cycle engines, the inlet and exhaust valve tappet clearances should also be checked periodically to limit acceleration forces.

Oil Leaks—Periodic inspection also includes the control of oil leaks and general appearance of the engine. Accumulation of oil and grease makes working conditions unsafe. If the engine cannot be worked on, it cannot be maintained properly.

These points cover the major periodic inspections of preventive maintenance. Each installation will have other minor but important inspections and adjustments to make. If these inspections are performed thoroughly, keeping the "barometers" of engine condition will be easier and more meaningful.

Parts of the engine that should be covered by "barometers" will vary with the installation. Every installation should use "barometers" to tell the condition of piston rings, pistons, cylinders, connecting rod bearings and main bearings. Considerable time and labor is required to dismantle these parts for visual inspection. And disassembly of these parts may be harmful in itself as mating parts are disturbed, dirt introduced, and reassembly performed improperly.

Compression Pressure, Lube Oil Consumption, Crankcase Pressure—Piston rings, pistons and cylinders are related in function and the "barometers" indicating their condition are compression pressure, lube oil consumption and crankcase pressure. If rings become stuck, or rings and cylinder walls wear to the point where the rings can no longer seal properly, blowby generally results. Left uncorrected, the condition can cause serious damage to an engine. Blowby can be detected by a decrease in compression pressure, an increase in crankcase lubricating oil consumption and an increase in crankcase pressure. On four-stroke cycle engines, leaking valves will also lower the compression pressure, but they will not affect crankcase pressure or oil consumption.

Scavenging Air Pressure and Exhaust Temperature—Port carboning is often a problem with two-stroke cycle engines. Two good barometers of this condition are scavenging air pressure and exhaust temperature. As the ports carbon up, air is restricted, and the scavenging air pressure rises. Exhaust temperatures will rise and detonation may occur at rated load. If the engine is shut down periodically for port cleaning, there will be times when little or no carbon is present.

Crankpin-to-Bearing Clearance—With today's precision machining methods, bearings last indefinitely, depending on operating and maintenance conditions. Faulty assembly is one of the most injurious factors; it can occur even with the most skilled mechanics. Therefore, it is unwise to dismantle bearings for inspection. A good way of checking connecting rod bearings without dismantling is the crankpin-to-bearing clearance method. This can be checked with a dial indicator and jack. Main bearings can be checked through web deflections.

Lubricating Oil Pressure—Another check on main bearings is the lubricating oil pressure. A substantial increase in bearing clearance will generally lower the supply pressure.

Bearing Deposits—A constant check on lube oil filters and the engine crankcase will indicate impending bearing failures through deposits of bearing materials. Many operators find spectrographic analysis of the oil useful in determining the condition of not only the rod and main bearings, but any wearing part such as camshaft bearings, cam follower bushings, turbocharger bearing and the like. Generally the material specification of each of these parts will differ from the others, and the experienced observer can usually tell which part effected a change in the analysis of the oil.

In the final analysis, the operator must decide how important each phase of preventive maintenance is to his operation and to what extent he uses it. But preventive maintenance will give him a better understanding of his engines and provide peace of mind in knowing their condition at all times.

This article originally presented as a paper at NGAA, Panhandle Plains Regional Meeting, November 30, 1956. ##

By Graphical Solution . . .

Heat Transfer Rates for Gases

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HEAT TRANSFER calculations for gases at elevated temperatures should make allowance for the viscosity and thermal conductivity of the fluids. Some simplified relationships, such as the Nusselt equation[3] dating back to 1909, are not adequate at higher temperatures.

The relationships used below involve the Prandtl number raised to the one third power and the viscosity ratio raised to the 0.14 power. The Prandtl number, $c\mu/k$, for most gases ranges between 0.65 and 0.80[2] while for saturated steam it is approximately 1.0 and for super heated steam varies up to 5.0.[4] An average value of the Prandtl number of 0.73 has been selected for the preparation of the design charts. Since the Prandtl number appears in the equations as a cube root power, the factor for a Prandtl number of 0.65 is $(0.65/0.73)^{1/3} = 0.963$. For a Prandtl number of 0.8, the factor is 1.030; for Pr = 1, the factor is 1.11. The viscosity ratio, $\mu/\mu w$, is generally so slight for gases that it has been assumed equal to 1.

Tube Side—The Sieder and Tate equation[6] (for Reynolds numbers above 10,000) is

$$\frac{h_i D}{k} = .027 \left(\frac{DG}{\mu}\right)^{0.8} \left(\frac{c\mu}{k}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (1)$$

By making use of Prandtl number value of 0.73 and ignoring the viscosity ratio, this equation simplifies to the following.

$$h_i = 13.75 \frac{k G'^{0.8}}{\mu_c^{0.8} d^{0.2}} \qquad (2)$$

Equation (2) uses the more conventional engineering units, such as centipoises, diameter in inches, and the mass velocity in pounds per second per square foot. It is necessary to multiply by the ratio of inside diameter/outside diameter in order to convert the heat transfer rate to that at the outer surface of the tube.

The accompanying design chart, Figure 1, has been set up to make use of a factor of 100k. Since the thermal conductivity for gases is between 0.005 and 0.05 the chart is prepared with nominal factors on the ordinate. These are always multiplied by factors ranging between 0.5 and 5.0. Figure 1 permits the direct reading of values at the inside of a ¾-inch OD x 14 BWG tube. For most commonly used tubes, the outside diameter factors are specified in the applicable chart. For other tube diameters it is only necessary to multiply by the inside tube diameter factor (d_f) times the ID/OD ratio. Where necessary a Prandtl number correction factor can be applied. The tube side chart is applicable to Reynolds numbers of 10,000 and up. The lower limits of the chart for three commonly used tube sizes are shown.

Shell Side—An accurate expression for the heat transfer rate for fluids flowing across the tubes in a baffled heat exchanger was presented by Donohue.[1]

$$\frac{hD}{k} = 0.22 \left(\frac{DG_e}{\mu}\right)^{0.6} \left(\frac{c\mu}{k}\right)^{1/3} \left(\frac{\mu}{\mu_w}\right)^{0.14} \qquad (3)$$

This equation can be simplified for gases to the form shown below:

$$h = 42.8 \frac{k G'_e{}^{0.6}}{d^{0.4} \mu_e^{0.6}} \qquad (4)$$

For bored shells the coefficient should be multiplied by a factor of 1.14.

A design chart, Figure 2, has been prepared in a manner similar to that for the tube side. A factor of 100k is incorporated. This chart is based on ¾-inch OD tubes on 15/16-inch triangular pitch. A table of tube factors for other tube arrangements is presented. A chart for variation of Prandtl number is also given.

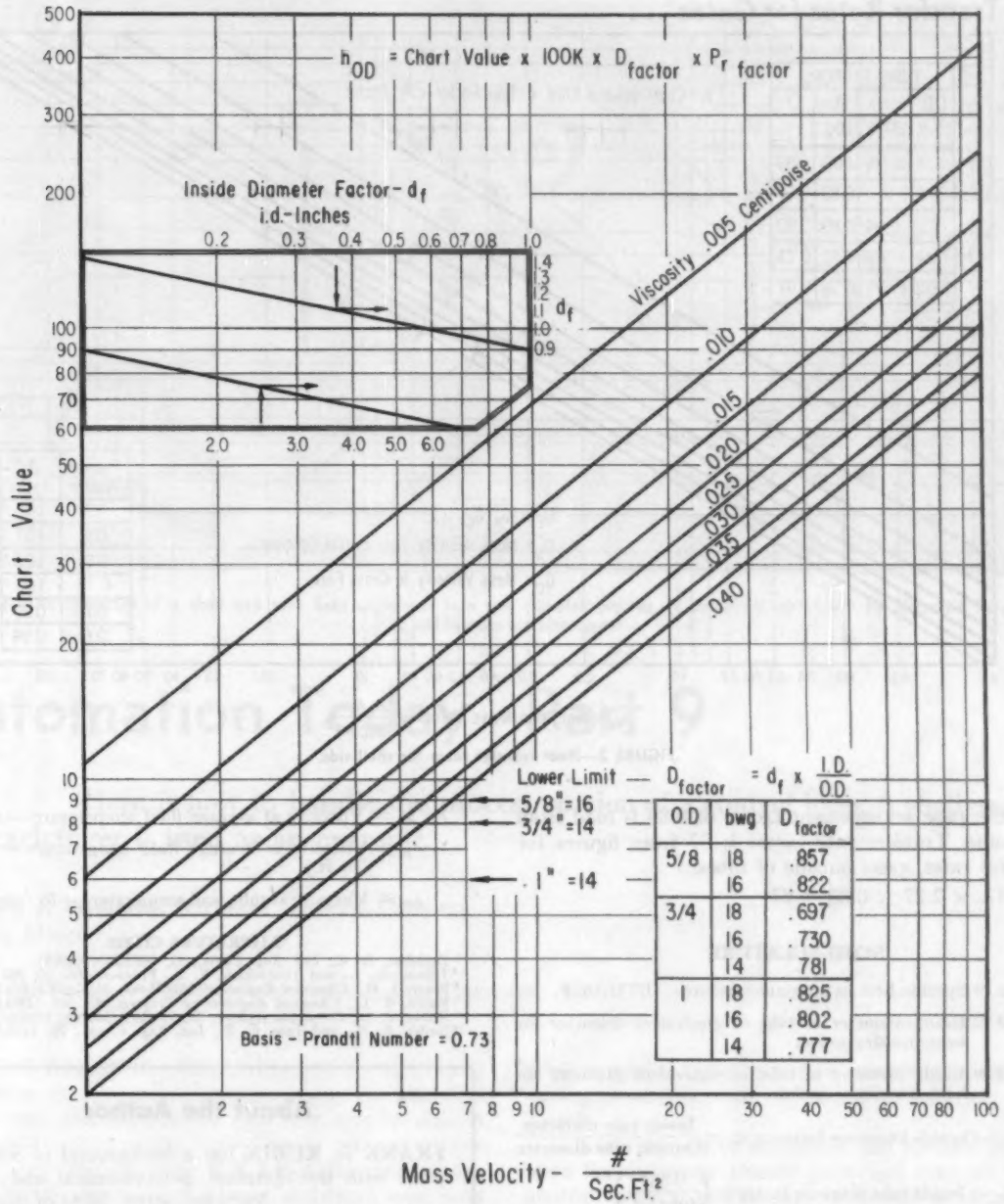
SAMPLE CALCULATIONS:

1. Given: CO_2 in a 1-inch OD x 14 BWG tube at G' = 5 lb./sec. sq. ft., temperature is 400 F.

Physical Property	Factor
Pr = 0.70	$(0.70/0.73)^{1/3} = 0.986$ which can be neglected since it is almost 1.0
k = .0175	(.0175 × 100) = 1.75
D_{factor}	0.777 from table of outside diameter factors
μ_c = 0.022 centipoise	read transfer rate factor 11.6 at G' = 5 from fiigure for transfer rates, gases in tubes.

h = 11.6 × 1.75 × 0.777 = 15.8

2. Given: CO_2 in a 2-inch OD x 11 BWG tube at G' = 10 lb./sec. sq. ft., temperature is 600 F.



O.D	bwg	D_{factor}
5/8	18	.857
	16	.822
3/4	18	.697
	16	.730
	14	781
1	18	.825
	16	.802
	14	.777

FIGURE 1—Heat transfer rates for gases inside of tubes. Inside diameter factor, d_f.

Physical Property	Factor
Pr = 0.69	$(0.69/0.73)^{\frac{1}{3}} = 0.982$ which can be neglected
k = .0227	$(.0227 \times 100) = 2.27$
μ_c = .027 centipoise	Read 17.5 @ G′ = 10 from figure for transfer rates, gases in tubes
ID = 1.76	$(0.584/1.76)^{0.2} = 0.80$ or read 0.80 from table of inside tube diameter factors
OD = 2.0	1.76/2.00 = 0.88

h = 17.5 × 2.27 × 0.80 × 0.88 = 28.0

3. Given: CO_2 in a baffled heat exchanger with ¾ inch O.D. tubes on a $\frac{15}{16}$ inch triangular pitch and an average temperature of 400 F. $G_e' = 5$ lb./sec. sq. ft.

Data are similar to that of Problem 1 except that the tube arrangement factor is 1.0. Transfer rate factor is 14.2 from figure for transfer rates, gases outside of tubes.

h = 14.2 × 1.75 × 1.0 = 24.8

4. Given: CO_2 in a baffled heat exchanger with 1 inch O.D. tubes on a 1¼ inch square pitch and an average temperature of 600 F. $G_e' = 30$ lb./sec. sq. ft.

Data are similar to that of sample problem 2 except

Heat Transfer Rates for Gases . . .

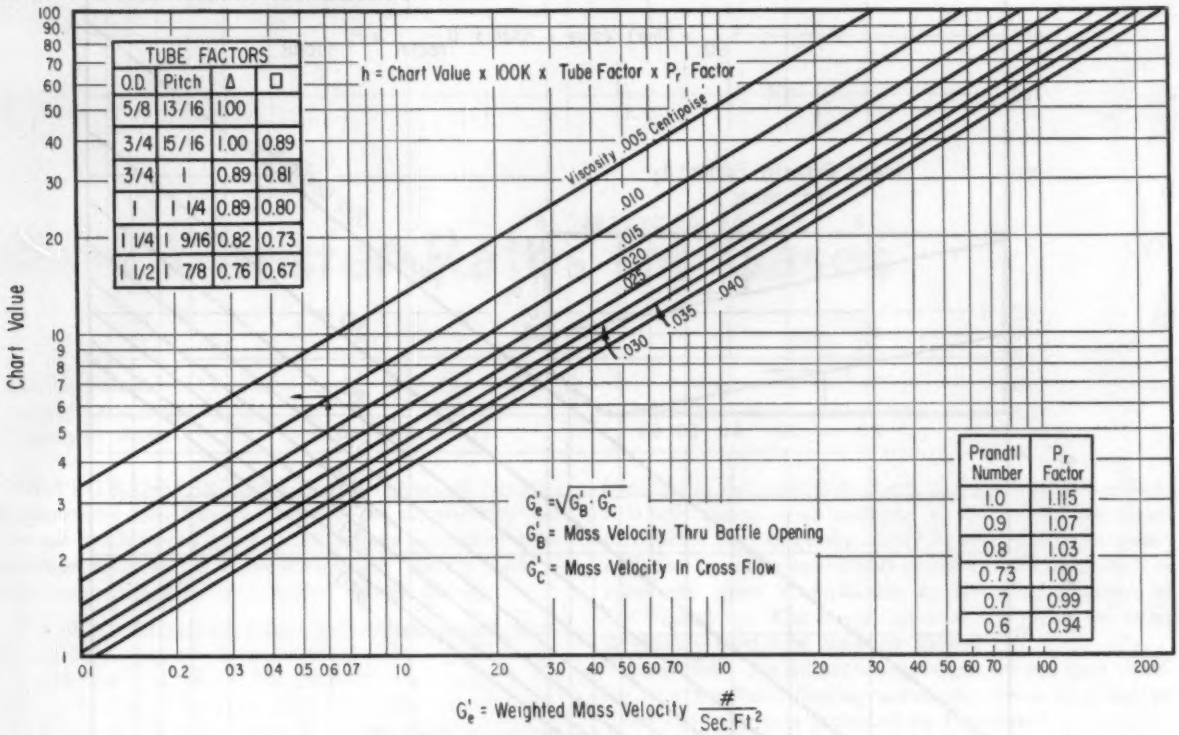

TUBE FACTORS
O.D. | Pitch | Δ | □
5/8 | 13/16 | 1.00 |
3/4 | 15/16 | 1.00 | 0.89
3/4 | 1 | 0.89 | 0.81
1 | 1 1/4 | 0.89 | 0.80
1 1/4 | 1 9/16 | 0.82 | 0.73
1 1/2 | 1 7/8 | 0.76 | 0.67
h = Chart Value x 100K x Tube Factor x Pr Factor
Viscosity .005 Centipoise
.010
.015
.020
.025
.030
.035
.040
Chart Value
Prandtl Number | Pr Factor
1.0 | 1.115
0.9 | 1.07
0.8 | 1.03
0.73 | 1.00
0.7 | 0.99
0.6 | 0.94
G'e = √G'B · G'C
G'B = Mass Velocity Thru Baffle Opening
G'C = Mass Velocity In Cross Flow
G'e = Weighted Mass Velocity # / Sec. Ft²

FIGURE 2—Heat transfer rates for shell-side.

that the tube arrangement factor of 0.80 is read from the table. Transfer rate factor is 37 from figures for transfer rates, gases outside of tubes.

$h = 37. \times 2.27 \times 0.80 = 67$

NOMENCLATURE

c = Specific heat at constant pressure — BTU/lb. F.

D = Inside diameter of tube or equivalent diameter for heat transfer — feet

d = Inside diameter of tube or equivalent diameter for heat transfer — inches

D_{factor} —Outside Diameter factor $= d_f \times \frac{\text{Inside tube diameter}}{\text{Outside tube diameter}}$

d_f = Inside tube diameter factor $= \left(\frac{0.584}{\text{tube i.d.}}\right)^{2.2}$

G = Mass velocity — lb./(hr.) (sq. ft.)

G' = Mass velocity — lb./(sec.) (sq. ft.)

G_e = Weighted shell side mass velocity $= (G_c\ G_b)^{0.5}$ — lb./(hr.) (sq. ft.)

G_e' = Weighted shell side mass velocity—lb./(sec.) (sq. ft.)

G_c = Cross flow mass velocity—lb./(hr.) (sq. ft.)

G_b = Mass velocity through baffle opening — lb./(hr.) (sq. ft.)

h = Coefficient of heat transfer at outer tube surface — BTU/(hr.)—(sq. ft.)—(F.)

h_i = Coefficient of heat transfer at inner tube surface — BTU/(hr.)—(sq. ft.)—(F.)

k = Thermal conductivity — BTU/(hr.) (sq. ft.) (F.)/ft.

Pr = Prandtl number — dimensionless $= \frac{c\mu}{k}$

μ_c = Viscosity at average fluid temperature — centipoises

$'\mu$ = Viscosity at average fluid temperature — lb./(hr.) (sq. ft.)

μ_w = Viscosity at tube wall temperature—lb./(hr.) (sq.ft.)

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[2] Hilsenrath, J., and Touloukian, Y. S., *Trans-ASME*, 76, 967 (1954).
[3] Perry, J. H., *Chemical Engineers' Handbook*, McGraw-Hill (1950).
[4] Rubin, F. L., *Chemical Engineering Progress*, 47, 541 (1951).
[5] Rubin, F. L., *Petroleum Refiner*, 35, 140-149 (March, 1956).
[6] Sieder, E. N., and Tate, G. E., *Ind. Eng. Chem.*, 28, 1429-1436 (1936).

About the Author

FRANK L. RUBIN has a background of some 15 years with the chemical, petrochemical and petroleum industries. Most of that time has been spent in the design of heat transfer equipment. Before joining Downington, he served for three years with Catalytic Construction Co. as senior job engineer on AEC projects, chemical plants, and refineries. He was also with The Lummus Co. in its Heat Exchanger division, and with Stauffer Chemical Co. in the Research division. He holds a B.A. from Brooklyn College, a B.S. degree in chemical engineering from Cooper Union School of Engineering, and has completed graduate studies at The Polytechnic Institute of Brooklyn. Rubin is a member of ASME and AIChE. He is married and has four children.

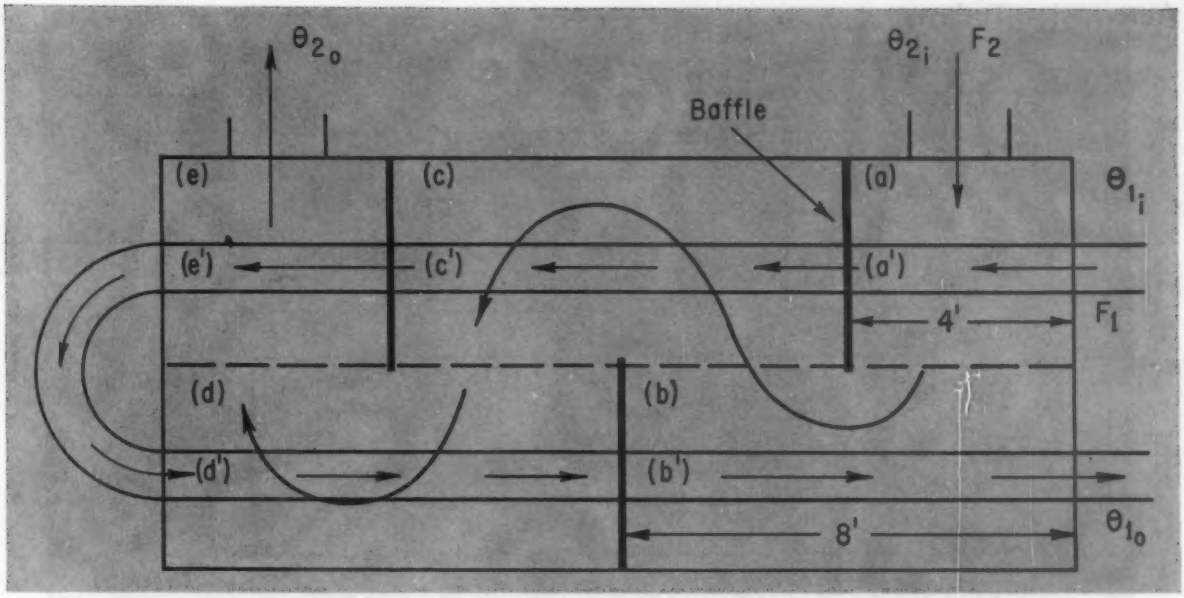

FIGURE 52—The operation of a shell and tube heat exchanger is a very complex process. A simplified model will be discussed here to point the way to more complex cases.

Automation Today—Part 9

Here is how to handle the process portion of a control loop. A shell and tube heat exchanger is used as an example.

Theodore J. Williams, Monsanto Chemical Company
St. Louis, Missouri
and
Joseph M. Young, Air Research and Development Command
USAF, New York City

WE HAVE NOW CONSIDERED in some detail each of the elements of the control loop, except the chemical process itself, and have shown how they may be treated in a control system study. We will now take up a consideration of this last and most important part of the block diagram, the chemical process, and detail some ways it may be treated as part of a control system. In addition, we will list some of the difficulties which it can contribute to the work of solution of such a problem.

For purposes of discussion the term "process" will be considered in its usual control systems sense; that is, it will include each of the unit operations as well as the standard unit processes of chemical engineering. Thus, *process control* can comprise the study of the control of any piece of chemical engineering equipment—be it a nitrator, a catalytic reactor, a distillation column, a mixing vessel, a heat exchanger, or any other such type of unit.

With this in mind, the reader may recall that we have already made a preliminary consideration of several different processes in our previous discussions. These included simple fluid flow, mixing, and heat transfer processes in Part 2, as well as a more detailed description of the distillation process. Finally, a more complete discussion of a mixing process as it fits into a control loop was given in Part 6.

It is our purpose in this article and the next to expand upon the discussion already given and consider how the general chemical process may be treated by detailing the formulation of the dynamic relations for several processes which are more complicated than those which have already been considered. Thus, it is hoped a method of attack for all processes in general may be visualized.

Although the process, as spoken of here, is the province of the chemical engineer and has been extensively studied by him, it is the least known part of the control loop from the viewpoint of the control engineer. While the responses of the controller, of the transmission lines, of the final control element or valve, and of the sampling mechanisms are either well known or can be readily postulated, that of the chemical process is relatively unknown. A consideration of those examples to follow will show this to be true. This is due to two factors: first, the extreme complexity of the exact expression of chemical reaction, fluid flow, and heat transfer relation dynamics; and second, because the chemical engineer has been

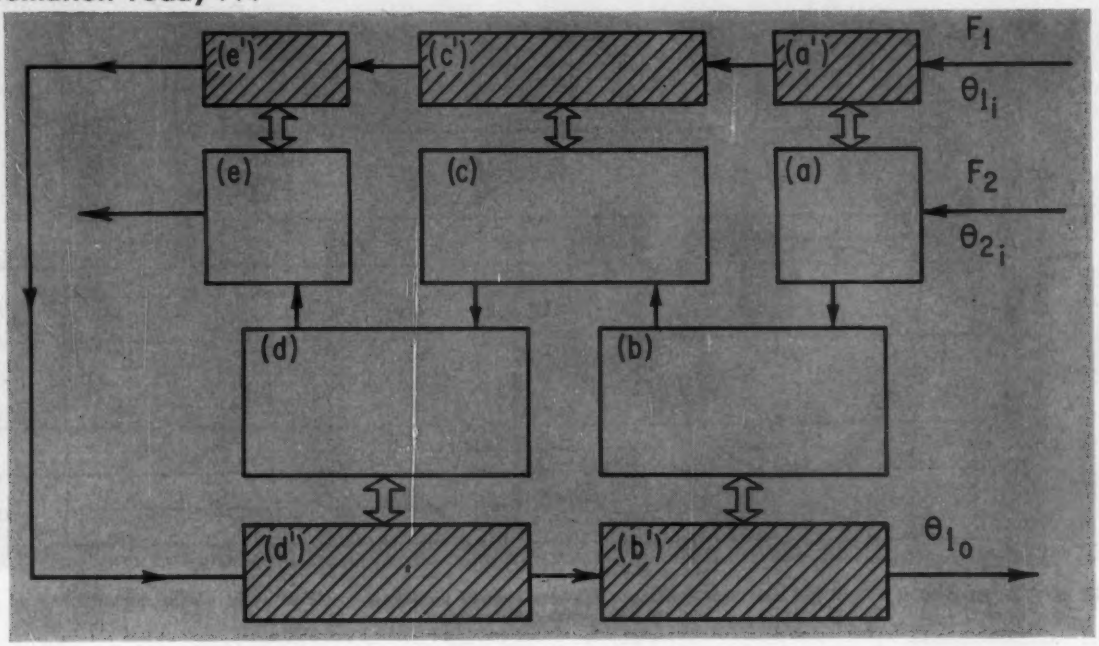

FIGURE 53—In this block diagram of a heat exchanger, the flow of fluid is represented by slender arrows while the heat transfer is represented by broad arrows.

mainly concerned with the steady-state case rather than the transient case.

GENERAL PROCEDURE

Just as with the less complex cases already considered, the first step in attacking the process control problem is to draw a block diagram of the process system showing the relationship of each of the major parts and indicating all flowing streams, energy transfers, or mass transfers involved in the process. The block diagram is the place where a majority of the necessary assumptions, needed in making the problem solvable by the means at hand, can and should be indicated.

Next, the mathematical equations governing the action of the pertinent variables of the process must be derived. It is best to keep these equations as general as possible during the initial setup of the problem to assure the most accurate representation of the system attainable with the block diagram already set up.

The family of equations representing the system is then collected and any additional simplifying assumptions made as required. It is to be emphasized that each assumption made here or previously tends to weaken the generality and applicability of the resulting solution to the system in question. They should not be made unless absolutely necessary to permit solution of the equations by the method desired, whether by hand methods or by computer.

It should also be kept in mind, particularly with chemical processes, that the solutions of any systems analysis should not be considered and used as the true representation of the system dynamics involved unless such a solution can be verified by experimental results on the same or similar systems. The high degree of nonlinearity of some chemical systems often nullifies the results of a system analysis, particularly if done under the assumptions of a linear system as is necessary for hand computational methods.

These concepts will be illustrated by discussing the systems analysis of a shell and tube exchanger[9] in this article and through the systems analysis of chemical reactors in the next.

A SHELL AND TUBE HEAT EXCHANGER

The operation of a heat exchanger, particularly a shell and tube type exchanger, is a very complex process with counterflow of fluids, liquid turbulence, and many other factors entering into the picture. Therefore, in order to make our discussion as straightforward as possible we will discuss a considerably simplified model. It is hoped, however, that the steps in the solution undergone here will make clear the procedure to be followed in the more complex case.

Heat exchangers have been extensively treated in a theoretical sense by Takahashi.[6,7] However, all of his models have been simpler than the one to be considered here. In addition, the concentric-tube, countercurrent exchanger, another simpler case, has been extensively studied by Mozley[4] and Cohen and Johnson.[1]

Let us consider the exchanger pictured in Figure 52 and allow the following assumptions:

1. Perfect mixing occurs in each of the shell side compartments a, b, c, d, and e.
2. Likewise, perfect mixing can be considered to occur in each of the tube side compartments a′, b′, c′, d′, and e′.
3. The arrangement of baffles is such that sections a and e for both tube and shell sides have one half the volume of sections b, c, and d, respectively.
4. The heat transfer coefficient is essentially constant over the temperature range involved.
5. Heat capacity and intersectional transfer of heat by the metal walls of the exchanger are negligible.

Of these assumptions, number 2 and number 5 are

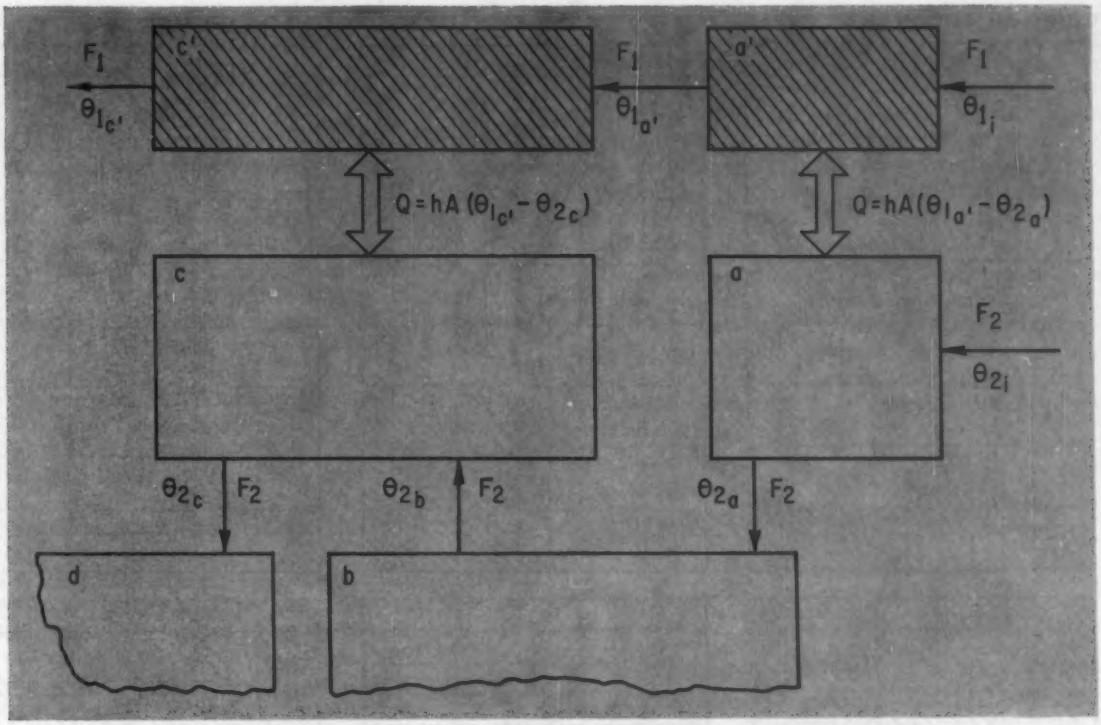

FIGURE 54—The inlet section of the block diagram is enlarged to show fluid flow and heat transfer in more detail.

probably the most serious. A tube such as section a′, b′, etc., usually undergoes "plug flow" rather than acting as a mixing vessel. Thus, its action could be better represented by a true time delay rather than a mixing lag. However, because of the amount of computing equipment available when this problem was undertaken, the mixing assumption was necessary to conserve equipment. We will discuss the reason for this more fully in a future article describing analog calculations.

The high conductivity of most metals can seriously discredit Assumption 5 if the ratio of metal to liquid in the exchanger is large. However, representation of this effect mathematically requires the use of partial differential equations and is again beyond the capabilities of the computing equipment we must use. Thus, both assumptions are absolutely necessary even at the risk of some nonapplicability of the results obtained.

In line with our recommended procedure let us first draw a schematic block diagram of the fluid and heat flow paths in the exchanger. Such a diagram is given in Figure 53, and in greater detail for a part of the exchanger in Figure 54. From these we can derive the necessary differential equations to describe the temperature history at every point in our model.

Derivation of Equations—If there were no heat transfer between sections, the temperature in any location could be specified by the relation:

$$\frac{d\theta}{dt} = \frac{F}{V}(\theta_i - \theta) \qquad (1)$$

Where F is the flow rate into the section, V is the section volume, θ_i is the input temperature and θ is the average section fluid temperature. We can readily see that the relation easily converts to our previously discussed first-order transfer function.

$$\frac{d\theta}{dt} + \theta\left(\frac{F}{V}\right) = \theta_i\left(\frac{F}{V}\right)$$

$$\theta\left(\frac{V}{F}\,p + 1\right) = \theta_i$$

$$\frac{\theta}{\theta_i} = \frac{1}{\tau p + 1}, \text{ where } \tau = \frac{V}{F} \qquad (2)$$

However, for our purpose here it will be best to keep our expression in the same form as Equation 1, since we must also consider heat transfer between the shell and tube sections. Therefore,

$$\frac{d\theta_t}{dt} = \frac{F}{V}(\theta_{t_i} - \theta_t) + \frac{Q}{c_{p_t}}$$

$$= \frac{F}{V}(\theta_{t_i} - \theta_t) + \frac{hA}{V\rho c_p}(\theta_s - \theta_t) \qquad (3)$$

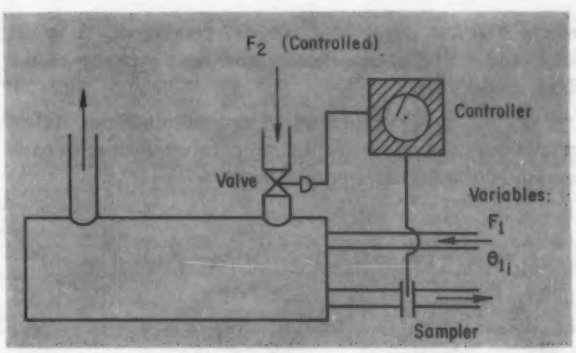

FIGURE 55—In a control arrangement for a heat exchanger, a controller can be made to vary the flow through the control valve and thus regulate the temperature in the sampler line.

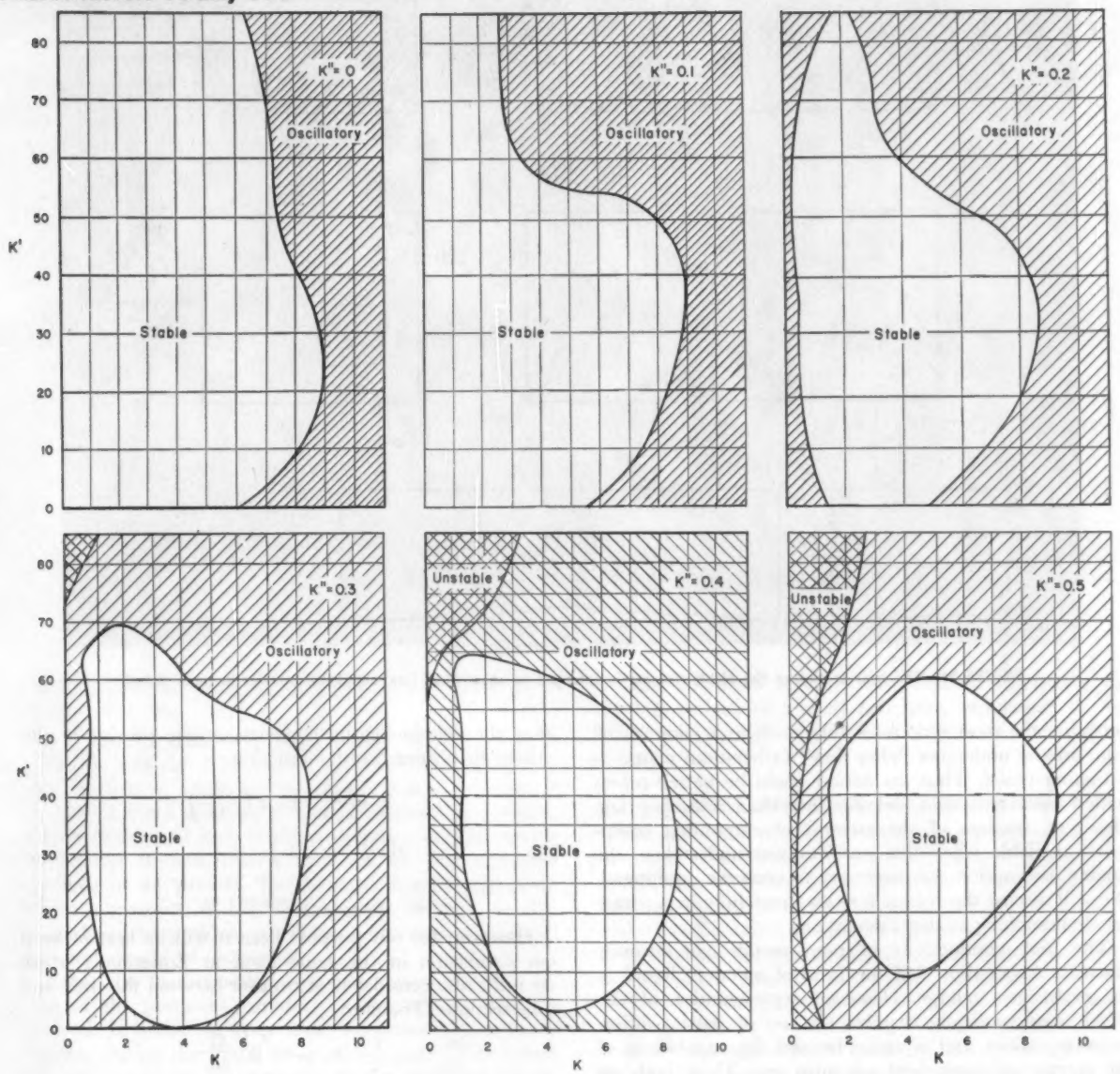

FIGURE 56—As the integral control constant (K") becomes larger, the region for stable operation exists over a more narrow range of derivative control constants (K') and proportional control constants (K).

where h is the usual heat transfer coefficient, A is the area, and ρ and c_p are density and heat capacity of the fluid, respectively.

We can, thus, write a set of ten simultaneous differential equations to specify the temperature history in each section of the exchanger, as follows:

$$\frac{d\theta_{2_{a'}}}{dt} = \frac{F_1}{V_{a'}}(\theta_{2_1} - \theta_{2_{a'}}) + \frac{hA_a}{V_{a'}\rho c_p}(\theta_{2_a} - \theta_{2_{a'}}) \quad (4a)$$

$$\frac{d\theta_{2_a}}{dt} = \frac{F_2}{V_a}(\theta_{2_1} - \theta_{2_a}) + \frac{hA_a}{V_a\rho c_p}(\theta_{1_{a'}} - \theta_{2_a}) \quad (4b)$$

$$\frac{d\theta_{2_{c'}}}{dt} = \frac{F_1}{V_{c'}}(\theta_{2_{a'}} - \theta_{2_{c'}}) + \frac{hA_b}{V_{c'}\rho c_p}(\theta_{2_c} - \theta_{2_{c'}}) \quad (4c)$$

$$\frac{d\theta_{2_c}}{dt} = \frac{F_2}{V_c}(\theta_{2_b} - \theta_{2_c}) + \frac{hA_b}{V_c\rho c_p}(\theta_{1_{c'}} - \theta_{2_c}) \quad (4d)$$

$$\frac{d\theta_{2_e}}{dt} = \frac{d\theta_{2_e}}{dt} = \frac{F_2}{V_e}(\theta_{2_d} - \theta_{2_e}) + \frac{hA_e}{V_e\rho c_p}(\theta_{1_{e'}} - \theta_{2_e}) \quad (4f)$$

$$\frac{d\theta_{1_{b'}}}{dt} = \frac{d\theta_{1_{b'}}}{dt} = \frac{F_1}{V_{b'}}(\theta_{1_{a'}} - \theta_{1_{b'}}) + \frac{hA_b}{V_{b'}\rho c_p}(\theta_{2_b} - \theta_{1_{b'}}) \quad (4i)$$

Next, let us establish the required control load by requiring that the output temperature of the hot stream, θ_{1_0}, be maintained as constant as possible during variations of its input rate, F_1, or input temperature, θ_{1_1}. We will accomplish this by varying the input rate of the cold stream, F_2. Figure 55 illustrates this arrangement.

As we have previously shown in Part 3, we can repre-

sent any possible theoretical control mode by the equation.

$$\Delta F_2 = KE(\theta) + K'pE(\theta) + \frac{K''}{p} E(\theta) \qquad (5)$$

where

$$E(\theta) = \theta_{i_0} - \theta_i \text{ desired}$$

Equation 5, plus the ten Equations 4a through 4j, thus comprise a family of eleven simultaneous differential equations which completely describe the response of the heat exchanger plus its associated controller. Notice that we have assumed that transmission line delays are negligible as are sampler and final control valve lags. If in an actual exchanger being studied such were not the case, an additional differential equation would be needed to represent each lag or delay involved.

In the computer setup used in this study, the proportional constant has the units of 100 ft.³/hr. F., that the input rate is changed by 100 K cubic feet per hour for each degree F. of output temperature error. Likewise the derivative constant is in units of 100 ft.³ sec./hr. F., and the integral constant is in units of 100 ft.³/hr., F., sec.

Solution of Equations—Our problem is thus reduced to finding the values of K, K′, and K″ which can give the best control of our model heat exchanger. The cross-flow of liquids between the various sections makes an analytic solution of our complete set of equations practically impossible. The use of computing equipment is, therefore, necessary and an analog computer is particularly recommended.[2]

The constants to be used in our problem are derived from one presented by Kern[3] with one allowance for our stated assumptions. They are given in Table 1.

Two methods present themselves. First, we might make a frequency response analysis as described in Part 6 of this series and used by Mozley. However, our problem complexity requires the use of the computer to obtain this response which nullifies much of the usual facility of this method. The second method, that of interpreting the transient response by the analysis method previously used by the authors, thus becomes the more feasible and will be used here.[5,8]

As described in Part 4, a linear system may have one of five responses to a step input. These are overdamped, critically damped, underdamped, sustained oscillation, and unstable or divergent oscillations. By recording these results for various settings of any two of the controller constants and then plotting on a graph with coordinates of one constant versus the other this resulting response as fields of controllable response, oscillatory, and divergent response, we can determine the best settings to use for the actual exchanger. This is especially valuable when a family of such curves is made up for various values of the third control variable thus completely defining the control relationship. Such a set of curves for this system is given in Figure 56.

As an example of this procedure, consider results of a series of solutions all of which used an integral constant of 0.4, that is 40 ft.³/hr., F., sec. A particular solution using a proportional constant, K, of 5 and derivative constant, K′, of 40 gives a quite satisfactory control. On the other hand, a K of 7 and a K′ of 60 gives an oscillatory response, while a K of 2 and a K′ of 80 is unstable; that is, the response is divergent. The area in the center defines all those combinations of K and K′ which will give a satisfactory control when K″ is given as 0.4. For a fuller discussion of this particular method of presentation, the reader is referred to the papers previously mentioned.[5,8]

The complete details of the analog computer setup for this problem will be given in a later paper of this series. Our purpose here has been only to indicate the steps in the method of attack. It will be worthwhile, however, to indicate the conclusions as drawn from this study and indicated by the graphs above. The recommended control ranges are:

a. Proportional gain, K, between 2 and 6.

b. Derivative gain, K′, between 10 and 40.

c. Integral gain, K″, between 0.2 and 0.4.

NOMENCLATURE

A — area of heat transfer surface in square feet
a, b, c, d, e — sections of shell side of exchanger
a′, b′, c′, d′, e′ — sections of tube side of exchanger
F — flow rate in pounds per second
h — heat transfer coefficient in BTU/F. second
i — as subscript, denotes input
K — proportional control constant, 100 ft.³/hr. F.
K′ — derivative control constant, 100 ft.³ sec./hr. F.
K″ — intergal control constant, 100 ft.³/hr. F. second
o — as subscript refers to output
p — d/dt
Q — heat transferred in BTU/second
V — volume in cubic feet
c_{p_t} — total heat capacity of the fluid in a section
c_p — heat capacity in BTU/F. lb.
$E(\theta)$ — error in output temperature
ΔF — required correction in flow rate
θ — temperature of stream in degrees F.
ρ — density in pounds per cubic foot
τ — time constant, second

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[3] Kern, D. Q., *Process Heat Transfer*, McGraw-Hill Book Company, New York, 1950, Example 7.4, p. 155.
[4] Mozley, J. M., *Industrial and Engineering Chemistry*, 48, 1035-41 (1956).
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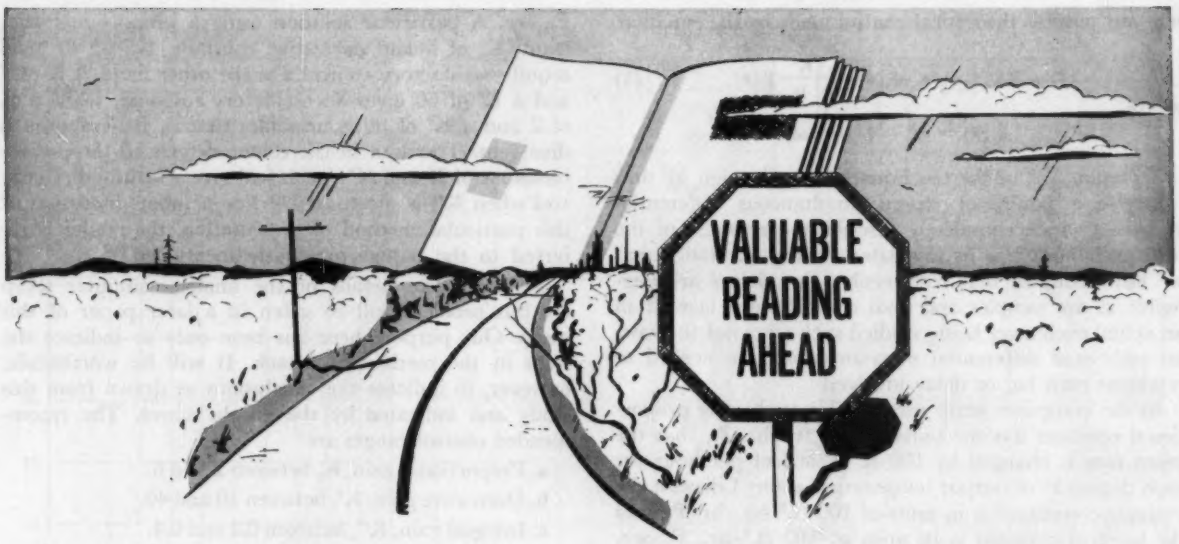
[7] Takahashi, Y., *Control Engineering*, 2, No. 5, 46-50, (May, 1955).
[8] Williams, T. J., Harnett, R. T., and Rose, Arthur, *Industrial and Engineering Chemistry*, 48, 1008-19 (1956).
[9] Young, J. M., M.S. Thesis, U.S.A.F. Institute of Technology, Wright-Patterson AFB, Ohio, 1956.

TABLE 1

Numerical Values Used in Computations

	Tube (1)	Shell (2)
Material	Raw Water	Distilled Water
Flow Rates, F (Initial)	280,000 lbs/hr or 78 lbs/sec or 4480 ft³/hr	175,000 lbs/hr or 48.7 lbs/sec or 2800 ft³/hr
Input Temperature, Θ_i (Initial)	75 F	93 F
Output Temperature, Θ_o (Initial)	80 F	85 F
Heat Capacity, c_p	1 BTU/lb F	1 BTU/lb F
Density, ρ	62.5 lbs/ft³	62.5 lbs/ft³
h	0.072 BTU/(sec)(°F)(ft²)	0.072 BTU/(sec)(°F)(ft²)
Volume, V	1.482 ft³(b′, c′, d′) 0.742 ft³(a′, e′)	3.1 ft³(b, c, d) 1.55 ft³(a, e)
Area, A	162 ft²(b′, c′, d′) 81 ft²(a′, e′)	162 ft²(b, c, d) 81 ft²(a, e)



A Real Life-Saver

Did you know that 17 percent of all worker accidents result from falls? A lot of these could possibly be due to carelessness or negligence. Therefore, you'll be interested in our "How To Do It" section this month which presents a picture story of eight safety tips to follow when using scaffolding. It's a must for your company safety program.

Keep Going to Page 236

Wonder What's Going On?

You won't have to wonder because when you finish reading "What's Happening in the Industry" every month, you'll know. This section offers you a complete run-down on those items that made the news last month, and it's presented in a concise manner that enables you to get the most information for the time you have invested.

Keep Going to Page 280

Who's Meeting Where

PETROLEUM REFINER's "Meeting Calendar" is an easy-to-read tabulation of what's coming up in the societies and associations that are of most interest to you. It's the type of thing you'll want to clip out and keep around so you can refer to it at a moment's notice.

Keep Going to Page 298

Where Did They Go?

Ever wonder what happened to some of your friends and acquaintances that you haven't heard from in a long time? Well, if they're in the refining-petrochemical-gasoline industry you'll read about them sooner or later in "What's Happening Among Men in Industry." Here's your surest-fire method for keeping up with personnel changes so be sure to . . .

Keep Going to Page 300

"Enterprise In Oil"

Have you ever wondered how Signal Hill, Calif., looked during the oil boom of the 1920s when drilling rigs were placed base to base? Well you can stop wondering. In "Reviewing New Books" this month there is a picture that was taken at Signal Hill during that time. It's from the exciting new book "Enterprise In Oil" which traces the history of Shell Oil Co. in America. Don't miss it . . .

Keep Going to Page 323

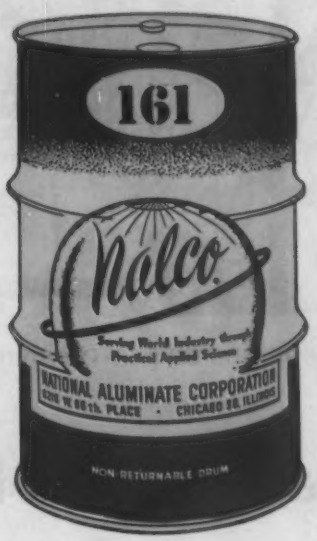
Motor Finally Quits

After the equivalent of 5787 years normal use, a much abused motor finally broke down, and one of the longest and most fundamental testing programs in history was almost over. You'll be interested in reading the account of how and why this motor and seven others were tested. It's all there for your information in this month's "New Equipment and Manufacturers Literature."

Keep Going to Page 352

Streamlining

CORROSION CONTROL SERVICES



. . . for oil production and refining

Nalco and Visco corrosion control chemicals and service have set a standard for the oil production and refining industries. The program we are starting in 1957 offers still greater benefits to our oil industry customers.

Beginning now!

VISCO will specialize in producing well corrosion control chemicals. NALCO will specialize in refinery corrosion control chemicals, and water flood and disposal treatment.

This emphasis on specialized service means that each Nalco or Visco Field Service Man has additional proven products to offer his customers. It means that his accounts will get full advantage of the research and development work, and the experience, of both companies. It means a more unified, concentrated approach to sales and service that will benefit the valued customers of both Nalco and Visco.

VISCO PRODUCTS COMPANY
A Unit of National Aluminate Corporation
2600 Nottingham at Kirby
Houston 5, Texas

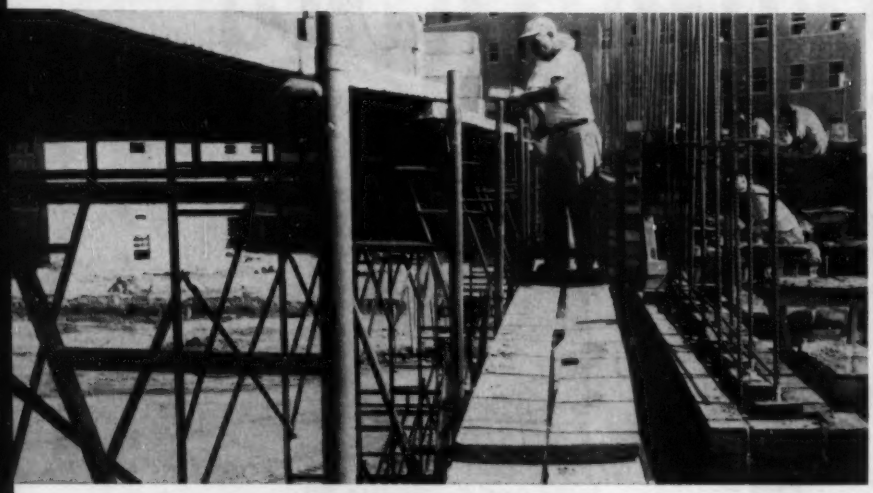
NATIONAL ALUMINATE CORPORATION
6216 West 66th Place
Chicago 38, Illinois

BRANCHES AND AFFILIATES IN CANADA, SPAIN, ITALY AND WEST GERMANY

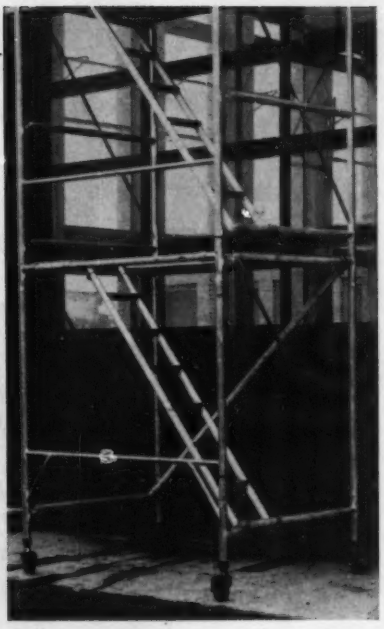
Visco® . . . FOR PRODUCING WELL CORROSION CONTROL

Nalco® . . . FOR REFINERY CORROSION CONTROL

How To Do It . . .



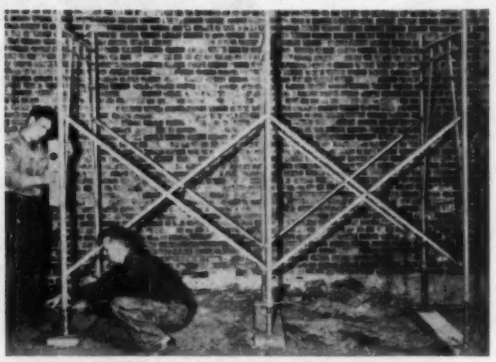
1. Substantial planking gives workmen confidence . . .



2. Lock caster brakes . . .

8 safety tips for using scaffolding

Seventeen percent of all worker accidents result from falls. Make your job safe by using these on-the-job practices.



3. Planking stills give firm footing . . .

4. Position sliding locks . . .

5. Oil bearing points . . .

6. Tighten coupler bolts . . .

Continued on Page 239

How it Works!

Only new Sarco TD steam trap uses kinetic energy of steam to close valve

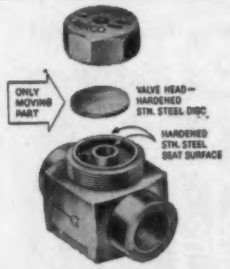
GAS MANTLES have been replaced by electric lights, steam locomotives by diesels, propeller planes by jets.

Now, the use of the kinetic energy of steam principle gives us a modern type of steam trap.

The Sarco TD obsoletes all other types for most 10 to 600 psi installations. For example, it operates without a valve closing device—no bucket, float, bellows, pins, levers or gaskets.

Glance below and you'll agree that no other steam trap is even similar to the Sarco TD!

For a trial installation—write today.



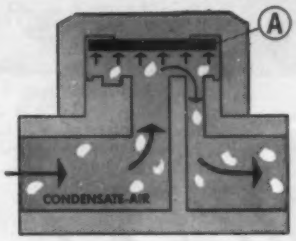
Only 3 parts...all stainless steel

Sizes ⅜ to 1"—each body is as small as a tee fitting! Capacity is determined not by a bulky body but by the effective orifice, valve action, pressure drop and condensate temperature.

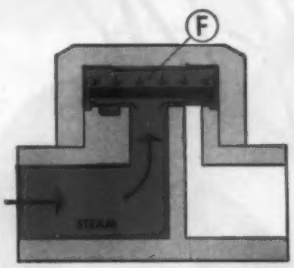
Many Advantages

1. *Practically no maintenance*—no valve mechanism, no narrow channels. Trouble-free simple design. Only 3 parts—all stainless steel.
2. *One trap for all pressures*—self-adjusting. One large capacity seat for 600 psi as for 10 psi. No changes or adjustments.
3. *Operates equally well on all loads*—on heavy, light or no condensate load. No prime to lose. No adjustments.
4. *No steam leak required*—to operate the Sarco TD. Closes tight against steam.
5. *Discharges at steam temperature and vents air* and air-steam mixtures at start-up and during operation.
6. *Freeze-proof*—when installed with outlet down, free to drain.

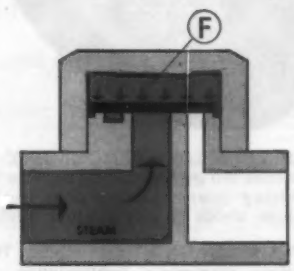
Only Sarco TD Thermodynamic Steam Trap Uses This Unique Operating Principle Which Permits Trouble-Free TD Design



1. Inlet pressure raises disc "A" from seat... immediate discharge of air and condensate at steam temperature.



2. Steam follows the condensate and the high velocity jet across the bottom of disc "A" creates a low pressure area (Bernoulli effect)...the jet is deflected into chamber "F" where it builds up pressure by recompression and this pressure acts on the top of the disc "A"...



3. Pressure in chamber "F", acting on full top area of disc "A", exceeds force of incoming steam and low pressure area under the disc...and immediately forces it down, closing the inlet. As condensation decreases the pressure in chamber "F", the disc rises and steps 1 or 2 repeat.

60-day trial convinces...No obligation...Use coupon!

SARCO

Steam Traps—Temperature Regulators—Strainers—Heating Specialties

SARCO COMPANY, INC., Empire State Bldg., New York 1, N. Y.

Please send me Sarco TD Steam Trap and strainer for 60-day trial. Size_____

For installation on_____

Name_____ Title_____

Firm_____

Address_____

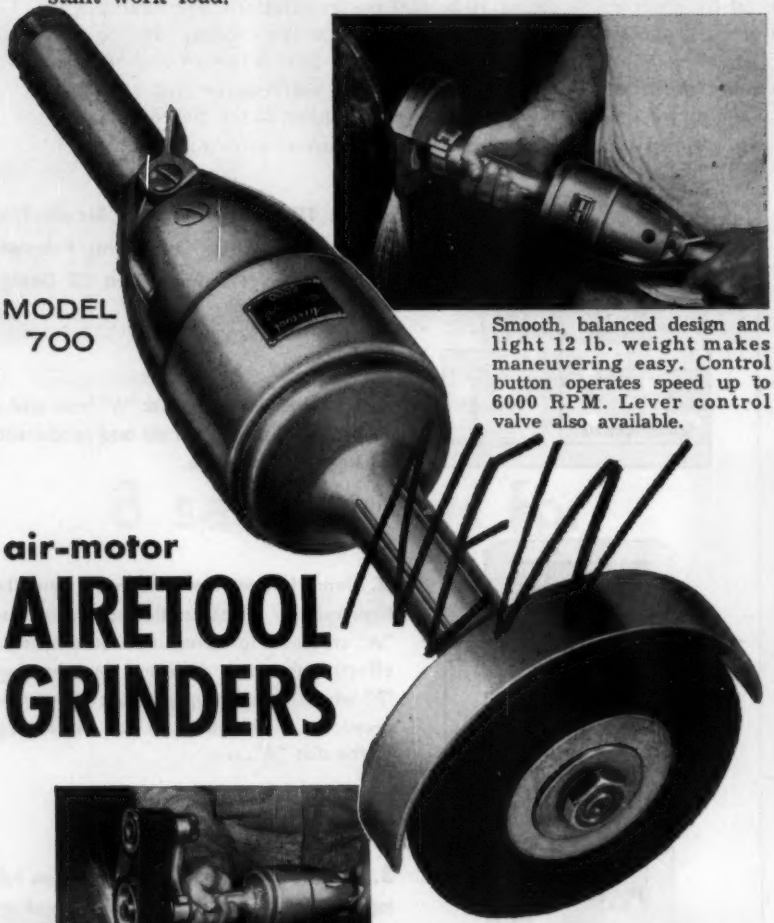
City_____ State_____

2184-C

For more data on advertised products, use Readers' Service Cards, last page.

TOUGH GRINDING MADE EASY...

Clean up castings and welds . . . deburr or do any portable snagging or grinding job faster and easier with this new Airetool grinder. It's light, rugged, easy-to-handle . . . packs plenty of power and speed — won't stall or heat-up under severe loads. Precision built Airetool air motor provides major operating economies and maintenance free service under constant work load.

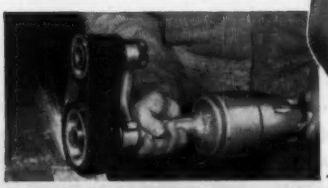


MODEL 700

Smooth, balanced design and light 12 lb. weight makes maneuvering easy. Control button operates speed up to 6000 RPM. Lever control valve also available.

air-motor

AIRETOOL GRINDERS



ABRASIVE BELT ATTACHMENT fits model 700 grinder. Ideal for fine finishing operations on dies, molds, seam welds or any contour surface.

RIGHT-ANGLE GRINDER Model 700A offers maximum convenience and working efficiency when grinding or sanding flat or curved surfaces.

Contact your AIRETOOL representative or write for Bulletin No. 61

AIRETOOL MANUFACTURING COMPANY
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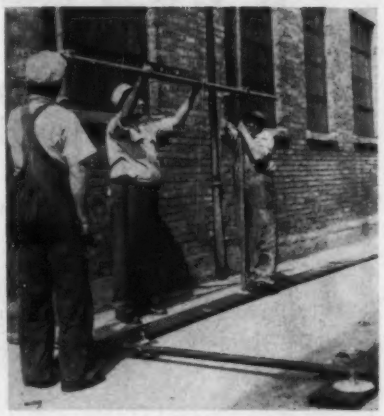
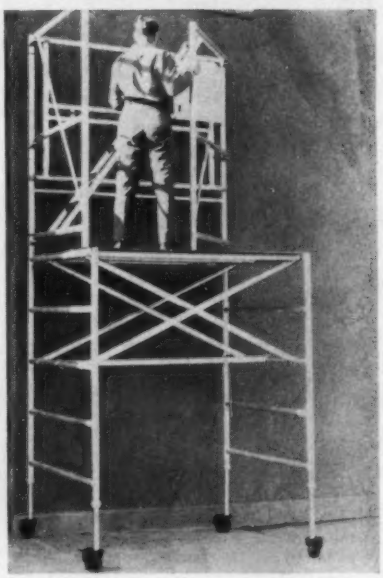
How to Do It...



7. Keep tubes level . . .



8. Never push scaffold while men are on it.

Photos and tips courtesy of The Patent Scaffolding Co., Inc., Long Island, N. Y.

This Tester Detects Oil In Your Exhaust Stream

Many plants remove oil from their exhaust steam by using an oil separator. The question often arises as to how much oil is being removed from the steam. Thus, it is advisable, before using the steam, to install a

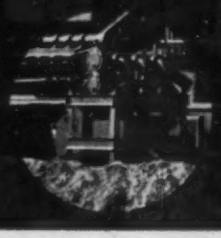
YOUR IDEAS ARE VALUABLE!

At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

For more data on advertised products, use Readers' Service Cards, last page.

WILFLEY SAND PUMPS

HELP CREATE **LOWER DRILLING COSTS**



The multiple cyclone unit, used in this oil drilling operation for removing sand and abrasive solids from drilling muds, makes possible 20% faster drilling, increased bit footage, 25% longer runs, reduced mud pump maintenance and many other cost-saving advantages. A vital factor in the economy of this operation is the Wilfley Sand Pump which provides: maintained high efficiency; continuous, trouble-free operation without attention; simple and speedy replacement of long-wearing parts.

Another example of Wilfley's contribution to lower operating costs throughout industry.

Wilfley Sand Pumps
"Companions in Economical Operation"
Wilfley Acid Pumps

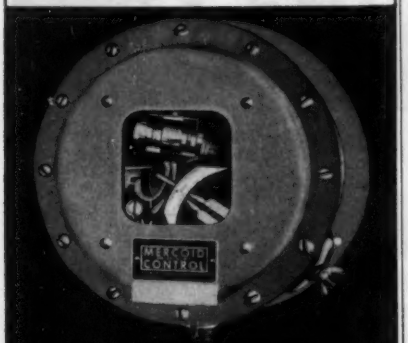
Individual Engineering on Every Application. Write, wire or phone for complete details.

A. R. WILFLEY and SONS, INC.

DENVER, COLORADO, U.S.A. • NEW YORK OFFICE: 122 EAST 42ND ST., NEW YORK CITY 17

For more data on advertised products, use Readers' Service Cards, last page.

MERCOID®
WEATHER RESISTANT
CONTROLS
VISIBLE
CALIBRATED DIAL
ON-OFF SWITCH POSITION
OPERATING POINT INDICATORS



for pressure or temperature

HERMETICALLY SEALED CONTACT
ZINC PLATED STEEL CASE
OUTSIDE ADJUSTMENTS

FOR OUTDOOR SERVICE OR OTHER APPLICATIONS (NEMA 1A, 2, 3, 4)

Drip Tight
Semi-Dust Tight
Weather Resistant
(Weather Proof)
(Splash Proof)
(Sleet Proof)
(Moisture Resistant)
(Rain Tight)
Weather Tight
(Hose Test)

Write for catalog No. 857W which also lists general purpose controls (NEMA 1) and explosion proof controls (NEMA 7, 9, 9A).

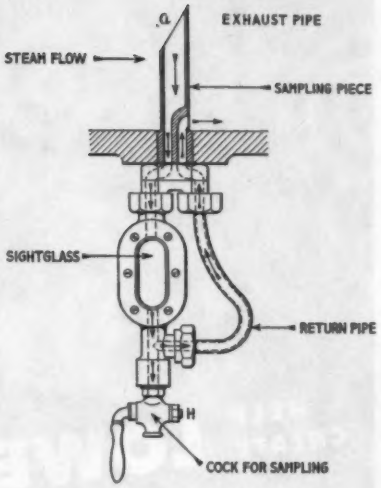
THE MERCOID CORPORATION
4201 Belmont Ave., Chicago 41, Ill.

How to Do It . . .

sampler before and after the separator.

The construction of the sampler is shown in the figure. The sampling piece is inserted in the steam line with its oblique face positioned in the direction of steam flow. A sight glass will disclose whether the steam is clean or non-translucent and oily. Samples may be taken by means of a cock and analysed.

This idea was submitted by:
Leo Walter
Nr. Stroud, Glos.
England



Hand Truck and Hoist Make Handling Safe

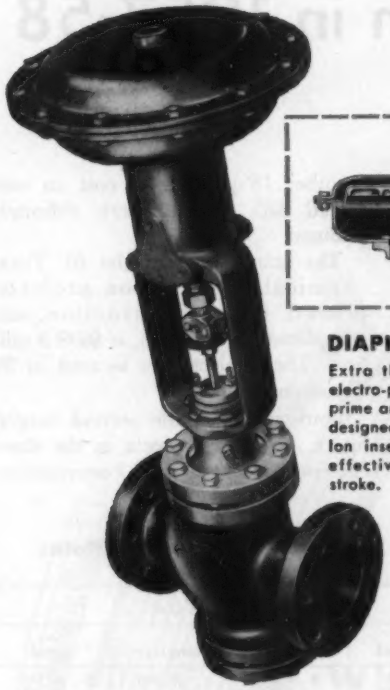
Safety is a by-product of mutual thinking. Through the years Ohio Oil Co.'s safety record has been backed by the fine thinking of its employees in all departments. This safety item was an idea developed at the Robinson refinery. It takes the aches out of backs and cuts the chance of injury. The refinery warehouse uses a hand truck and electric hoist to properly manage heavy, shifty objects. This kind of thinking boosts safety records and safety thinking is safety progress. Photo by Clarence Keller. Idea through courtesy of Eugene L. Price, Editor, *The Beacon,* publication of The Ohio Oil Co.

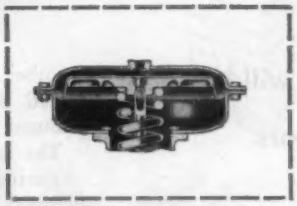
For more data on advertised products, use Readers' Service Cards, last page.

Any Way You Look At It

FISHER® Control Valves

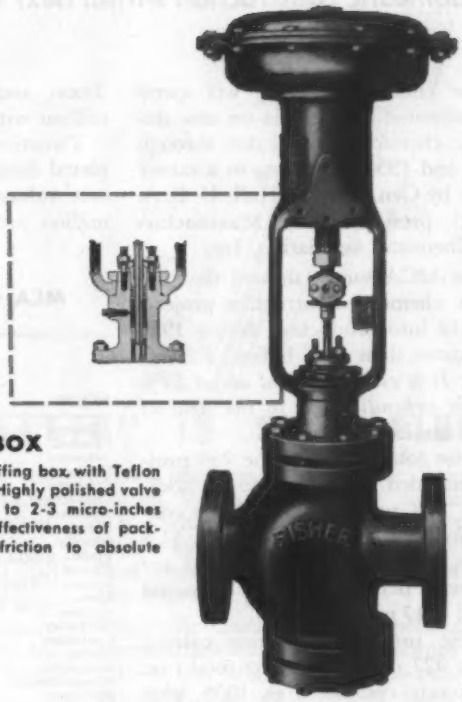
are your BEST BET!





DIAPHRAGM ASSEMBLIES

Extra thick steel casings are zinc electro-plated, iridited and then given prime and final paint coats. Specially designed molded diaphragm with nylon insert gives practically constant effective area throughout valve stroke.

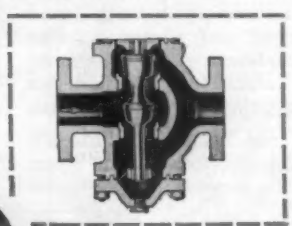


STUFFING BOX

Bolted gland stuffing box with Teflon V-Ring packing. Highly polished valve stem is finished to 2-3 micro-inches RMS to insure effectiveness of packing and keep friction to absolute minimum.

BODY ASSEMBLIES

Large capacity bodies with accurately machined inner valves are individually "ground in" under customer's specified temperature conditions.



Realizing their importance in the control system, Fisher has given careful attention to design and construction of diaphragm control valves. Any way you look at it — from the standpoint of durable construction or accuracy of performance—Fisher Diaphragm Control Valves are your best bet.

FISHER GOVERNOR COMPANY

Marshalltown, Iowa • *Woodstock, Ontario*

World Leader in Research for Better Pressure and Liquid Level Control

For more data on advertised products, use Readers' Service Cards, last page.

Who's Building . . .

Next Construction Boxscore to appear in April issue.

Chemical Building to Boom in 1957-58

MCA survey estimates $2.5 billion will be spent on domestic construction within next two years.

The chemical industry will spend an estimated $2.5 billion on new domestic chemical construction through 1957 and 1958, according to a survey made by Gen. John E. Hull, U. S. A. (Ret.), president of the Manufacturing Chemists' Association, Inc.

The MCA survey showed that domestic chemical construction projects brought into production during 1956 cost more than $1.1 billion. *Editor's Note: It is estimated that about 53% of this expenditure is in the field of petrochemicals.*

These totaled 354 of the 760 projects included in the survey. An additional 278 projects now under construction will cost an estimated $1.8 billion, and another 128 projects are definitely planned at an estimated cost of $717 million.

These projects are being carried out by 327 companies. The total cost of projects completed in 1956, plus those under construction or definitely planned for completion within the next two years, will be more than $3.6 billion.

Geographical Distribution.

Gen. Hull pointed out the increasing nationwide scope of the industry as indicated by the survey. The projects included are in 406 communities in 44 states.

Texas, which is the third ranking chemical producing state, led in the number of projects included. During the calendar year 1956 the industry completed chemical construction projects valued at $154.6 million in Texas, and will add another $485.3 million within the next two years.

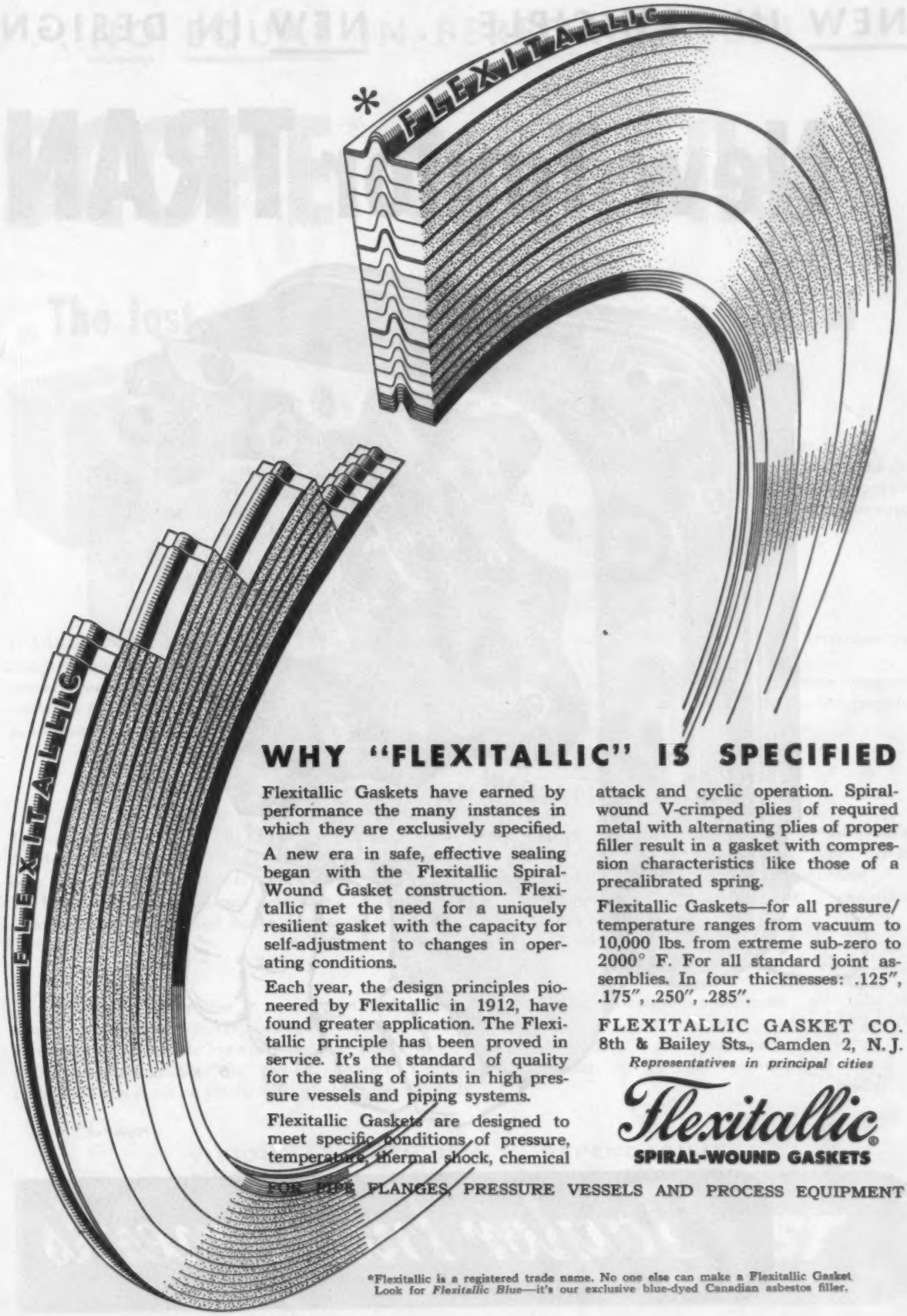
Twenty-seven projects were completed during 1956. Thirty-eight projects valued at an estimated $400.3 million are now under construction. Another 16 projects to cost an estimated $85 million are definitely planned.

The total value of the 81 Texas chemical construction projects, planned, under construction, and completed during 1956, is $639.9 million. The projects are located in 29 Texas communities.

Louisiana had the second largest figure, with 39 projects in the three categories, located in 17 communities,

MCA Chemical Industry 1956 Construction Survey by States

STATE	BY THOUSANDS			
	Planned	Under Construction	Completed	Total
Alabama	$ 1,300	$ 16,300	$ 28,900	$ 46,500
Arizona	19,200	1,000	.....	20,200
Arkansas	1,500	1,350	1,200	4,050
California	37,800	89,000	118,700	245,500
Colorado	.....	20,462	500	20,962
Connecticut	1,700	1,900	100	3,700
Delaware	3,000	4,700	2,000	9,700
Florida	42,425	171,250	24,250	237,925
Georgia	24,500	44,450	25,000	93,950
Idaho	.....	10,000	3,000	13,000
Illinois	6,130	65,150	18,950	90,230
Indiana	23,500	12,825	12,040	48,365
Iowa	5,000	750	1,400	7,150
Kansas	.....	.....	8,750	8,750
Kentucky	3,000	41,470	37,250	81,720
Louisiana	80,100	279,150	19,410	378,660
Maine	.....	.....	9,650	9,650
Maryland	.....	25,200	20,300	45,500
Massachusetts	1,189	5,450	16,375	23,014
Michigan	100,900	6,950	33,500	141,350
Minnesota	5,100	12,000	16,000	33,100
Mississippi	15,500	1,000	2,500	19,000
Missouri	22,000	30,350	29,650	82,000
Montana	2,200	.....	500	2,700
Nebraska	.....	.....	2,500	2,500
Nevada	.....	.....	15,000	15,000
New Hampshire	.....	.....	.....	.....
New Jersey	6,450	82,925	49,750	139,125
New Mexico	6,250	21,000	19,250	46,500
New York	16,187	32,082	40,800	89,069
North Carolina	11,500	4,850	1,250	17,600
North Dakota	.....	.....	.....	.....
Ohio	5,200	131,650	90,047	226,897
Oklahoma	3,000	1,000	24,100	28,100
Oregon	.....	3,050	6,700	9,750
Pennsylvania	11,500	76,690	27,075	115,265
Rhode Island	.....	.....	500	500
South Carolina	2,500	.....	750	3,250
South Dakota	.....	.....	.....	.....
Tennessee	51,000	19,250	65,550	145,800
Texas	85,000	400,300	154,661	639,961
Utah	25,000	3,750	25,350	54,100
Vermont	.....	.....	.....	.....
Virginia	500	62,600	28,615	91,715
Washington	2,100	.....	37,330	39,430
West Virginia	27,300	94,600	107,595	229,495
Wisconsin	.....	150	491	641
Wyoming	.....	.....	9,000	9,000
Location Unspecified	58,500	7,300	24,950	90,750
Total	$718,031	$1,781,904	$1,161,189	$3,661,124



WHY "FLEXITALLIC" IS SPECIFIED

Flexitallic Gaskets have earned by performance the many instances in which they are exclusively specified.

A new era in safe, effective sealing began with the Flexitallic Spiral-Wound Gasket construction. Flexitallic met the need for a uniquely resilient gasket with the capacity for self-adjustment to changes in operating conditions.

Each year, the design principles pioneered by Flexitallic in 1912, have found greater application. The Flexitallic principle has been proved in service. It's the standard of quality for the sealing of joints in high pressure vessels and piping systems.

Flexitallic Gaskets are designed to meet specific conditions of pressure, temperature, thermal shock, chemical attack and cyclic operation. Spiral-wound V-crimped plies of required metal with alternating plies of proper filler result in a gasket with compression characteristics like those of a precalibrated spring.

Flexitallic Gaskets—for all pressure/temperature ranges from vacuum to 10,000 lbs. from extreme sub-zero to 2000° F. For all standard joint assemblies. In four thicknesses: .125", .175", .250", .285".

FLEXITALLIC GASKET CO.
8th & Bailey Sts., Camden 2, N. J.
Representatives in principal cities

Flexitallic®
SPIRAL-WOUND GASKETS

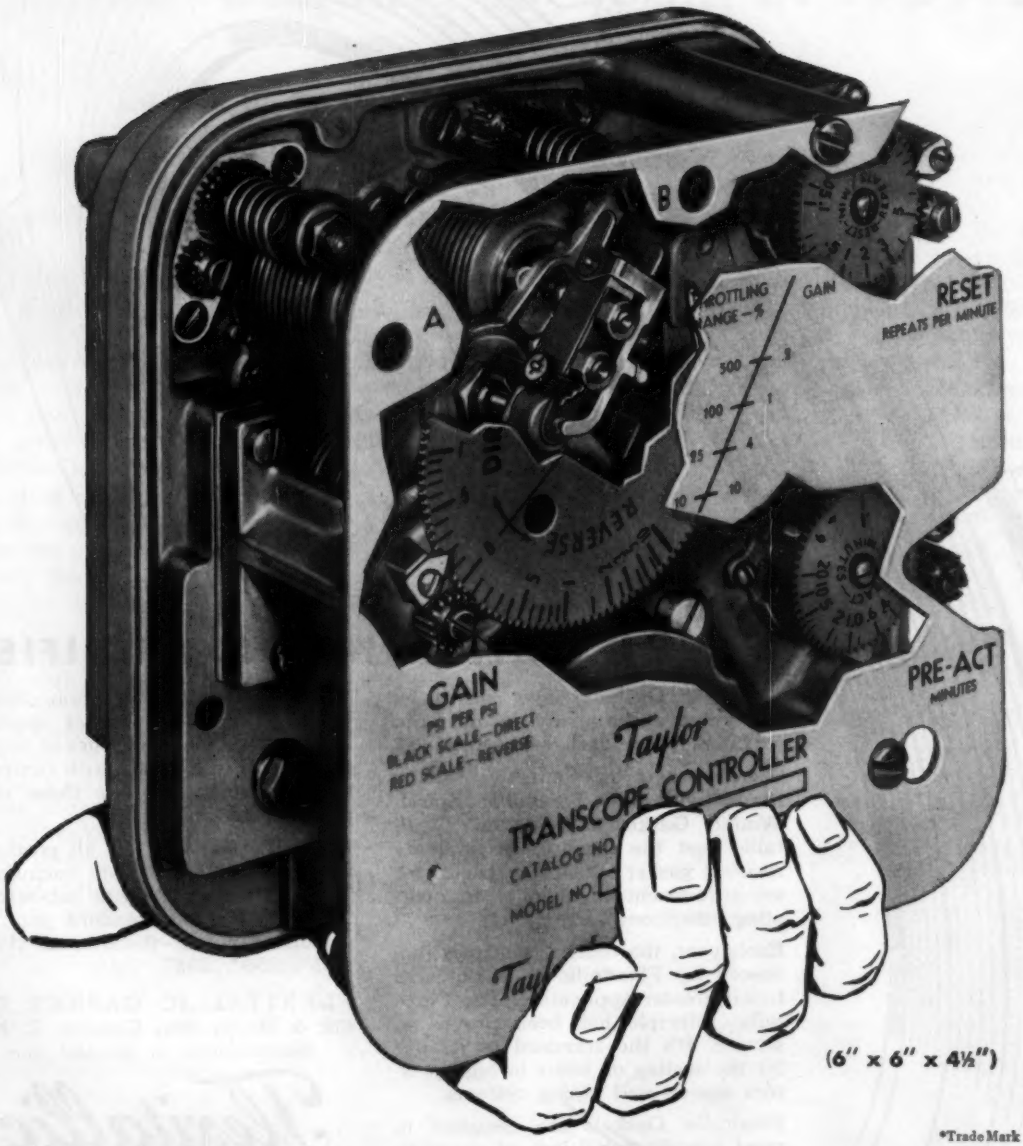
FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Flexitallic is a registered trade name. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue*—it's our exclusive blue-dyed Canadian asbestos filler.

For more data on advertised products, use Readers' Service Cards, last page.

NEW IN PRINCIPLE . . . NEW IN DESIGN

New Taylor TRAN



(6" x 6" x 4½")

*Trade Mark

Taylor Instruments

. . . NO EQUAL IN PERFORMANCE!

SCOPE* Controller

The last word in Pneumatic Process Control

SUPERIOR PERFORMANCE

1. Especially suited for short spans of measurement . . . ideal for time constants of modern processing . . . outstanding in insensitivity to ambient temperatures.
2. Exceptionally fast and responsive to adjustments—vital on start-ups.
3. Pre-determined mathematical settings made possible by precision manufacture of gain, reset and Pre-Act units. Adjustments stay put.

EXCEPTIONAL ADAPTABILITY

1. Adaptable to changes in process requirements . . . complete interchangeability of components so you can convert from simplest to most complex forms of control *in the field* . . . in minutes.
2. Instrument action reversed by merely rotating a dial. Plugs into Transet Indicators and Recorders or locally mounted manifolds.
3. Designed to meet the demand for more compact instruments, it is ideally suited for use in graphic panels and scanning and logging systems.

SIMPLE MAINTENANCE

1. Rugged bellows assembly, keyed in place, moves the dynamically balanced force plate . . . friction-free bending member never needs maintenance.
2. Husky die-cast aluminum assemblies, accessible stainless steel nozzle and baffle, hardened stainless steel reaction members. Dust and moisture-proof case.
3. Ease of alignment—smooth-acting, screw-driver adjustment because of ball bearing construction.
4. Easy to understand . . . easy to get at . . . simplifies maintenance training.
5. Integral cut-off relay is a built-in feature.

The **Transcope Controller** is so compact, so simple, so smooth and responsive to adjustments yet so accessible for every purpose that it really "gets" you. But the "pay-off" doesn't come until you put it on your toughest job. Only then can you realize how contagious enthusiasm can become.
Write for **Bulletin 98278.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

VISION • INGENUITY • DEPENDABILITY

MEAN ACCURACY FIRST

For more data on advertised products, use Readers' Service Cards, last page.

KAMLOK
QUICK COUPLERS
633-A
633-B
OPW CORPORATION
OPW
CINCINNATI 25, OHIO
SLIPS ON
CAM TIGHTENS
HOLDS TIGHT
NEVER FAILS
The Fastest, Safest, Surest Coupling Known
634-A
633-F
634-B
633-D
633-C
633-E
633-G
KAMLOK
BRONZE • ALUMINUM • MONEL
STAINLESS STEEL • SEMI-STEEL
ALL STYLES OF ADAPTORS FIT IN ALL STYLES OF COUPLERS OF THE SAME SIZE.
Perfectly tight, no leak connection in seconds. Kamloks couple and uncouple instantly regardless of "hook-up".
Write for Free Bulletin F-10
JORDAN CORPORATION
Industrial Sales Division of OPW Corp.
6013 Wiehe Road • Cincinnati 13, Ohio

Who's Building...

and with a total value of $378.66 million. California was third, with 65 projects in 34 communities, with a total value of $245.5 million.

Also ranked among the first 10, according to value of investment, were: Florida, $237,925,000; West Virginia, $229,495,000; Ohio, $226,897,000; Tennessee, $145,800,000; Michigan, $141,350,000; New Jersey, $139,125,000, and Pennsylvania, $115,265,000.

Product Classification.

Consolidation of national figures for facilities completed during 1956, under construction, and planned shows that the industry is currently making its largest investment, $862 million, in organic chemicals. The second largest investment, $816 million, is in the field of inorganic chemicals. The third largest, $465 million, is for chemically produced metals or metallic compounds, exclusive of aluminum, processed uranium, copper, and ferroalloys.

Investment in other product classifications are: fertilizer chemicals, $407 million; plastics and resins, $395 million; chemical fibers, $279 million; synthetic rubber, $210 million; basic chemicals from petroleum and natural gas, $96 million; and miscellaneous chemicals, $36 million.

Particularly significant is the fact that the chemical industry in 1956 completed new research facilities at a cost of $42 million, is currently building $37 million more, and has definitely planned new facilities at an estimated cost of nearly $16 million—a total of $95 million.

Chemical Construction Completed, Under Construction, or Planned in 1956 by States and Categories

STATE	MILLIONS OF DOLLARS					
	Organic Chemicals	Plastics and Resins	Synthetic Rubber	Fertilizer	Others	Total
Texas	251.1	121.4	137.2	0.8	129.5	640.0
Louisiana	92.1	28.4	14.7	20.8	222.7	378.7
California	56.8	31.7	18.0	49.7	89.3	245.5

MCA Chemical Industry 1956 Construction Survey by Category

CATEGORY	BY THOUSANDS			
	Planned	Under Construction	Completed	Total
Fertilizer Chemicals	$ 74,525	$ 130,420	$ 201,900	$ 406,845
Inorganic Chemicals	247,889	361,450	206,700	816,039
Organic Chemicals	184,567	366,992	310,481	862,040
Metals	46,000	288,697	130,950	465,647
Plastics and Resins	24,700	245,720	124,197	394,617
Synthetic Rubber	30,000	156,300	23,750	210,050
Textile Fibers	26,200	177,000	75,700	278,900
Others	84,150	55,325	87,511	226,986
	$718,031	$1,781,904	$1,161,189	$3,661,124

Texaco Slates New 40,000-BPD Refinery at Anacortes

Construction of a new 40,000-bpd refinery will begin about March 1, near Anacortes, Wash., The Texas Company has announced. Engineering for the refinery has already begun and the plant is scheduled for completion by January, 1959.

Texaco's newest refinery, to be known as Puget Sound Works, will be built on a site of approximately 760 acres, about three miles east of Anacortes, on the Olympic Peninsula.

The new refinery will manufacture automotive gasolines, jet fuel, diesel, furnace and heavy fuel oils and liquid petroleum gas, for the rapidly expanding markets in the Northwest and West Coast areas, W. B. Logan, Manager of the Refining Department's Pacific Coast Division in Los Angeles, said.

Texaco's Los Angeles Works at Wilmington, Calif., has been able to supply its needs on the West Coast

For more data on advertised products, use Readers' Service Cards, last page.

Get the Best

NORRIS QUALITY FITTINGS

NORRIS
75 YEARS of SERVICE

W.C. NORRIS MANUFACTURER, INC.

TULSA, OKLAHOMA

BRANCHES:

GREAT BEND, KANSAS; CORPUS CHRISTI, HOUSTON, KILGORE, ODESSA, WICHITA FALLS, TEXAS;

Since NORRIS 1882

OKLAHOMA CITY, OKLAHOMA
SALEM, ILLINOIS; CASPER, WYOMING;

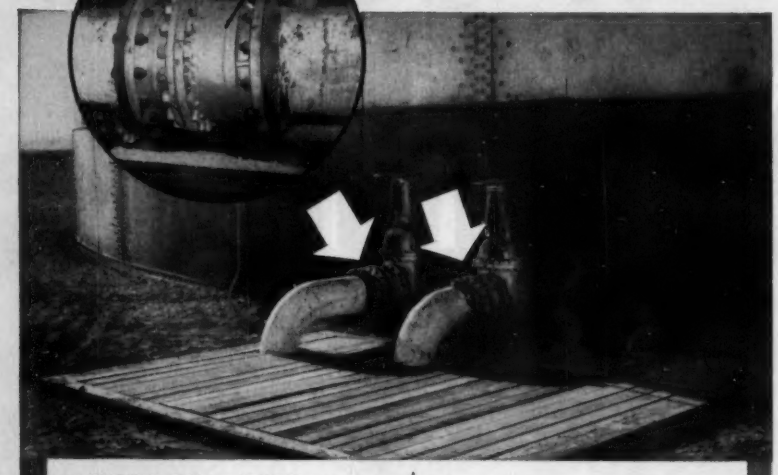
WEST COAST DIST.: REPUBLIC SUPPLY CO. OF CALIF., LOS ANGELES

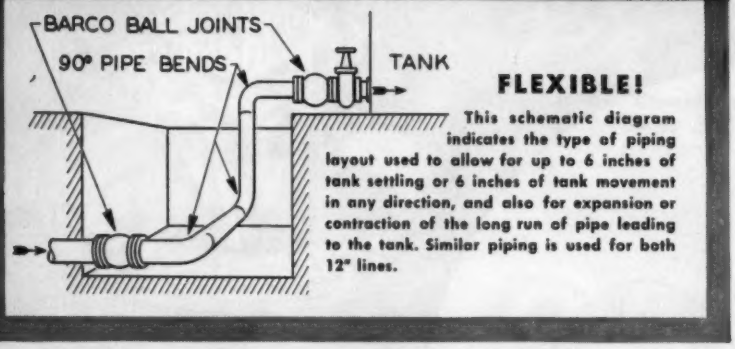
NEW

12" BARCO

Flexible Ball Joints

(also new 8" and 10" sizes)





FLEXIBLE!

This schematic diagram indicates the type of piping layout used to allow for up to 6 inches of tank settling or 6 inches of tank movement in any direction, and also for expansion or contraction of the long run of pipe leading to the tank. Similar piping is used for both 12" lines.

Built to Handle Big Tank Jobs!

One of the first places where twelve of Barco's new large size Flexible Ball Joints have been put to use is on three 170,000 bbl. West Coast tanks which receive crude from a new 12,000 ft. long 24" off-shore pipeline. As shown in the above photograph, each tank is connected by two 12" lines—each fitted with two 12" Barco Ball Joints. The joints provide the following advantages:

1. **Allow for tank settling or tilting. Also pipe expansion.**
2. **Isolate tanks against earthquake shock; also pump shock.**
3. **Maximum protection against Fire Hazards.**

For detailed information about new 8", 10" and 12" Barco Ball Joints, see our nearest representative or WRITE FOR NEW CATALOG 215B. Joints available in Bar-Ductile metal or steel; flanged or welding ends. 15° angular flex.

FOUNDED 1908 BARCO PRODUCTS BACKED BY EXPERIENCE

BARCO MANUFACTURING CO.

542D Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints

In Canada: The Holden Co., Ltd., Montreal

Who's Building...

area up until now, officials said. However, the area's rapid development now calls for a second West Coast refinery, they said.

Contracts for the general construction work have been awarded to the Bechtel Corporation of San Francisco.

Texaco's new refinery will include a fluid catalytic cracking unit with a capacity of 18,000 barrels per calendar day, a catalytic reforming unit with a capacity of 7000 bpd, a catalytic polymerization unit, alkylation unit, and a hydrotreating unit, together with the necessary tankage, docks, utilities, and other miscellaneous facilities. The dock will be large enough to handle two tankers at the same time.

The Northwest refinery will bring Texaco's total number of refineries in the United States to 12, exclusive of two asphalt plants.

British Petroleum Plans Refinery Near Montreal

BP (Canada) Ltd., a subsidiary of The British Petroleum Co., Limited, London, England, has annouced the acquisition of a 600-acre site near Montreal for a 30,000-bpd refinery.

These plans represent the first venture of the international BP Group into marketing and refining in North America. Imported crude oil will be used.

It is expected that the refinery will have a capacity of approximately 30,000 bpd. The total investment in the refinery when it goes on stream is likely to be in excess of $30 million.

The BP Group's principal sources of crude oil production are in the Middle East. Total crude oil produced by the Group during 1956 was more than one million barrels per day. This compares with an estimated total Canadian production during 1956 of approximately 600,000 barrels per day.

The BP Group operates 14 refineries, in Great Britain, Aden, Australia, Belgium, France, Germany, Israel and Italy.

Skelly Oil Co. will build a 3000 to 4000-bpd Perco HF Alkylation unit at its El Dorado, Kan. refinery. The unit, which is licensed by Phillips Petroleum Co., uses

When you plan for a reliable source of hydrogen, take advantage of this experience:

More than 50 hydrogen plants have been built by Girdler

In your search for *experienced* engineer-constructors to provide dependable hydrogen facilities, let these facts guide you: Girdler has built most of America's hydrogen plant capacity installed during the past ten years. Big and small . . . for low-purity or for high-purity hydrogen . . . these plants provide undisputed evidence of Girdler's know-how and ability. Call or write us for complete information.

The **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION . . . Design, Engineering, Construction of Hydrocarbon Processing Plants, Gas Producing Plants, Chemical Plants. Specialty Catalysts. Offices: New York, San Francisco • *In Canada:* Girdler Corporation of Canada Limited, Toronto, Ontario

For more data on advertised products, use Readers' Service Cards, last page.

CORROSION

TYPE	HOW TO IDENTIFY
GALVANIC	Localized deep grooves or pits, often at contact between dissimilar metals.
UNIFORM	Uniform attack—may be on only one part.
INTERGRANULAR	Attack at grain boundaries.
PITTING	Rapid, deep pitting at several small areas. May be uniform or highly localized.

Why you can conquer all four kinds of corrosion with Goulds chemical pumps

When you buy Goulds Fig. 3715 chemical pumps you can build *specific* protection against all four types of corrosion.

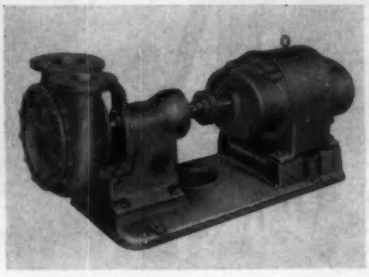
Match the pump metal to your liquids. You can have the *entire* fluid end of the pump made of 316 stainless, Gould-A-Loy 20, nickel aluminum bronze, iron, iron with stainless trim or nickel aluminum bronze trim. These metals from stock. Any machinable alloy on application.

All machined parts in all metals held to same close clearances permitting economical alloy changes in the field . . . the entire liquid end or any component as conditions warrant.

Choosing from this wide range of metals, you can combat the different corrosive actions of hot acids, alkalies, slurries, sizes, or whatever other corrosive liquids you pump.

Match pump size to job

You can get Goulds Fig. 3715 in 9 sizes: capacities to 720 GPM, heads to 200 ft. Other features of Fig. 3715: water-jacketed support head permits handling liquids at 350°F; impeller clearance can be adjusted without dismantling the pump. For more information, write for Bulletin 720.4.



These larger pumps also fight corrosion

For larger capacities or heads, you can get these other Goulds pumps in metals that resist specific corrosion:

Fig. 3405—single stage, double suction; 19 sizes; capacity to 6400 GPM, head to 425 ft. Bulletin 721.6. Popular sizes available in 316 stainless steel from stock.

Fig. 3305—two stage, opposed impellers; 8 sizes; capacity to 1200 GPM, head to 1000 ft. Bulletin 722.6.

Fig. 3189—single stage, open impeller; 11 sizes; capacity to 1080 GPM, head to 180 ft. Bulletin 720.4.

Goulds PUMPS INC. Seneca Falls New York

Branches: Atlanta • Boston Chicago • Houston New York • Philadelphia Pittsburgh • Tulsa

West Coast Representative: Goulds Pumps Western, Portland, Ore.
In Canada: The A. R. Williams Machinery Co., Ltd. in all principal cities.

Who's Building . . .

hydrofluoric acid as a catalyst, and is the first alkylation process to employ air cooling. Cost of the unit was not announced, but completion is scheduled for early 1958.

Petroleos Mexicanos (Pemex) has announced the following construction projects: installation of a 25,000-bpd catalytic cracking plant at its Mexico City refinery; modernization of its Arbol Grande refinery; construction of a 25,000-bpd catalytic cracking plant and new electric power and steam plants at the Ciudad Madera (Tampico) refinery; and completion of the 300-Mmcf-per-day gas absorption plant at Ciudad Pemex, in the state of Tabasco.

Mobay Chemical Co.'s plant at New Martinsville, W. Va., is being expanded on schedule. The first addition of production units for making isocyanate chemicals will be completed this month.

Texas Eastman has started construction of a neopentyl glycol plant at Longview, Texas. An appreciable drop in the 45-cents-a-pound price originally established for pilot production is expected by the company with the advent of commercial production.

Monsanto Chemical Co. and the Japanese firm of Mitsubishi Kase Kogyo have completed construction of a jointly owned polystryene plant near Nagoya. The new unit which is the first of its kind in Japan has a monthly capacity of 250 tons of polystryene and was completed at a cost of $694,000.

Western States Refining Co. has placed a 1000-bpd Houdriformer on stream at its 3500-bpd North Salt Lake City refinery. Within two days after start-up, the reformer was producing 97.0 F-1 octane leaded Houdriformate from low octane straight-run naphtha cuts of Rangely and other Rocky Mountain crudes.

The new Houdriformer is part of a $1 million modernization program announced by Western States. It is one of the refinery's three principal units. The others are a crude unit and a thermal cracker.

Douglas Oil Co., California, is making substantial additions to its Bakersfield and Paramount plants. At the Bakersfield refinery, work has started on a $1.5 million expansion program, including a new 12,000-bpd crude distillation unit, new laboratory, a Unifining unit and a ten percent increase in thermal cracking capacity. Completion of the new Unifining unit and increasing of the thermal cracker capacity is expected by June of this year.

At the Paramount asphalt plant, the crude distillation unit capacity is being increased by another ten percent. In addition, a new research laboratory and a new emulsion unit are being built. Also under way are feasibility studies looking toward the building of a new asphalt refinery at Paramount which would be completed in about three years, in time to meet the rising demand for asphaltic products.

Petroleum Chemicals, Inc., is planning a regional office building to house operating and engineering department

For more data on advertised products, use Readers' Service Cards, last page.

VALVES

to control anything but rain!

My Boss buys a lot of valves — or has it done — and he sure likes to buy them from J&L Supply.

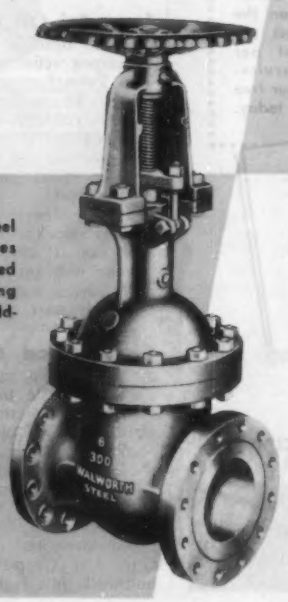
"Give those people the facts," says he, glancing at my new raincoat, "and they'll come up with the perfect valve for handling anything but rain."

"And what do we mean by the 'facts'?", says I, eager to be a good secretary.

"Oh," says he tolerantly, "to get the perfect valve for exacting jobs, we just give J&L complete service information: size and flange rating and facing, fluid to be handled, operating pressure, maximum temperature, any special corrosive conditions — that sort of thing."

"Oh?" says I.

"Young lady," says he, sensing my confusion, "don't expect to learn all about valves in a day. J&L Supply usually recommends Walworth, and Walworth was making and improving valves before your great granddaddy was born!"



Walworth Cast Steel Gate Valve, Series 300. Can be supplied with Roller Bearing Yoke and Butt Welding End.

29-G

Jones & Laughlin

SUPPLY DIVISION - Tulsa

SERVING THE UNITED STATES AND CANADA

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Specify Protective Coatings With a Slide Rule!

Use Carboline's Engineering Approach!

When an engineer wants an accurate calculation, he doesn't guess – he uses his slide rule.

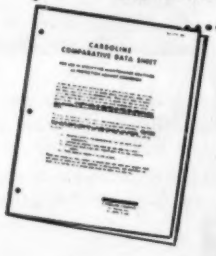
When you buy or specify protective coatings, don't *guess* about the system that is best for your needs. Follow the engineer's example, and use a "slide rule" – a careful, point-by-point comparison of the facts on these important features:

- **SOLIDS CONTENTS**
- **COVERAGE PER GALLON**
- **MIL FEET PER GALLON**
- **MIL THICKNESS PER COAT**
- **RESISTANCE TO CORROSIVE**
- **ESTIMATED RECOATING CYCLES**
- **COST PER SQUARE FOOT PER YEAR OF SERVICE**

Carboline data sheets and recommendations give you all the facts necessary to arrive at a sound, clear-cut conclusion. You will find, on all of these basic points, Carboline Coatings score high. Many Carboline users have discovered the true effectiveness and long range economy of Carboline Coatings by this scientific comparison approach.

Sales Offices in Boston, New York, Pittsburgh, Detroit, Chicago, Houston, Denver, Los Angeles, San Francisco, Toronto and other leading cities.

FREE — a 12" x 18" comparative data chart . . . your "slide rule" for judging protective coating systems . . . permitting quick, accurate evaluation of systems on the basis of cost per square foot per year of service. Write for your free copy today.



carboline COMPANY

345 Thornton Ave., St. Louis 19, Mo.

Manufacturers of PHENOLINE, POLYCLAD, RUSTBOND PRIMERS

Specialists In Corrosion Resisting Coatings and Linings

Who's Building . . .

personnel and staff at its Lake Charles, La., plant.

The building is part of an over-all $60 million expansion program for P. C. I. Previously announced were installations for producing butyl rubber, ethylene, ethylene oxide and anhydrous ammonia. The office building is expected to cost in excess of $500,000.

Design was done by the engineering and architectural staff of Continental Oil Co., which owns P. C. I. jointly with Cities Service. P. C. I. is now obtaining bids with construction expected to start in about a month and completion set for the early part of 1958.

The Du Pont Co., Wilmington, Del., has exercised an option to purchase a plant site of about 600 acres on the Mississippi River 27 miles upstream from New Orleans and just west of the town of Laplace, La. The site, known as the Belle Point plantation, will provide for possible future expansion of Du Pont's Polychemicals Department's business. The department manufacturers plastics materials, industrial chemicals, and intermediates used in making nylon.

The site is located on the north bank of the Mississippi and borders on the Airline Highway leading to New Orleans. It is about four miles west of the Bonnet Carre Spillway between Lake Pontchartrain and the river.

Texas Gas Corp. has erected a new isopentane tower at its Winnie, Texas plant. The new tower is expected to have a production capacity of approximately 350 bpd of pure isopentane. This gives the plant a total capacity of 475 bpd.

Engineered and designed by Winnie plant engineers, all fabrication and construction work on the unit, with the exception of the actual erection of the tower, was done by Texas Gas personnel.

The isopentane tower contains 60 bubble cap type trays to perform the separation and fractionation required to produce pure isopentane.

Imperial Oil Co. has awarded a contract to build a Powerformer unit at its Winnipeg refinery to Foster Wheeler Ltd. The Powerformer is the main item in a $4 to $5 million construction program at the refinery which the company announced in November. The program will also provide for an increase in the refinery's over-all capacity from 15,000 to 17,500 bpd.

Foster Wheeler Ltd. will be doing engineering work during the winter months and actual construction of the Powerformer will get under way in the spring. The unit is expected to be completed in the early part of 1958.

Commerce Oil Refinery Corp. appears to be making some headway in its long battle to overcome local opposition to its Jamestown, R. I. refinery. Legal obstacles have blocked plans for the refinery ever since the company announced them over a year ago. The latest block, however, a dispute over a pier for the facility, appears to be on the road to a solution.

An interested observer to the battle is Gulf Oil Corp. who just recently announced that it has signed a contract to

Sinclair-BAKER RD 150

PLATINUM CATALYST

guaranteed high yields and long life at high octane levels.

REGENERATES IN SITU . . !

The initial efficiency plus regenerative features of Baker's RD150 are unique and of major importance to the petroleum industry. RD150 assures greater yields at high octane levels . . . exceptionally long periods of operation . . . regeneration in situ! RD150 is a joint development of Baker & Co., Inc. and Sinclair Research Laboratories. It is presently being used by such companies as Sinclair, Socony and Pure Oil.

The very extensive facilities for manufacture and refining in modern Baker plants, provide full assurance of prompt deliveries and service.

Upon request, a Baker representative will be glad to give you detailed information.

BAKER & COMPANY, INC. CATALYSTS

113 ASTOR STREET
NEWARK, N. J.

THE HUB OF PLATINUM METALS RESEARCH

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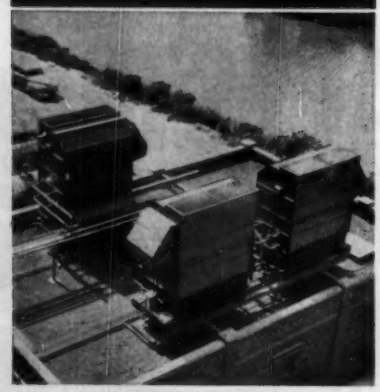
IMPROVED CONDENSING and Cooling of Reflux



Get Better Control of Distillation Product

● Liquid or vapor temperatures are always held constant by the Niagara "Balanced Wet Bulb" control method of evaporatively cooling or condensing, which automatically varies the cooling effect proportionately to the load. The distillation product is therefore uniform throughout all changes in climatic conditions the year around; it is the same in the heat of summer as in the freezing cold of winter. Continuous maximum production is thus insured.

Non-condensibles are effectively separated at the condensate outlet, with notable sub-cooling after separation for greater vacuum pump efficiency.

NIAGARA AERO HEAT EXCHANGERS give sustained full capacity in cooling and condensing with no dependence on cooling water . . . eliminating problems of water supply, availability, temperature, or quality.

Write for full information; ask for Bulletin 120. Address Dept. PR-5

NIAGARA BLOWER COMPANY
405 Lexington Ave., New York 17, N.Y.
District Engineers in Principal Cities of U. S. and Canada

Who's Building. . .

sell crude oil to commerce and to buy back products. It is expected that this announcement will somewhat weaken opposition to the plant.

Originally, plans called for a 30,000-bpd unit, but it is reported that capacity may be increased to as much as 40,000-bpd. Gulf will have nothing to do with financing or constructing the plant which is expected to go on stream about two years after actual building gets under way. At the present time, The Lummus Co. is conducting basic engineering studies for the facility.

Jordanian Economics Ministry has decided to invite foreign companies to bid for the construction and the operation of a refinery. It is reported that French companies will not be eligible as Jordanian-French diplomatic relations have been severed.

Texas Asphalt and Refining Co. has placed on stream its asphalt refinery on the Houston Ship Channel. It has a capacity of 5000-bpd. Gulf Coast distillate is mixed with heavy Boscan crude yielding 53 percent asphalt products in the combined charge. Pona Engineers, Inc., Houston, did the building.

Goodrich-Gulf Chemicals, Inc., plans to convert its synthetic rubber plant at Institute, W. Va., to cold rubber. Capacity of the plant is expected to run about 50,000 tons per year. Goodrich-Gulf purchased the plant from the government a little over a year ago at a cost of $11 million, and at that time capacity was rated at 122,000 tons per year of GR-S type rubber.

Conversion will be finished by early 1958 and will cost about $2 million with another $1.5 million for new power facilities.

Cia. Petrolera Shell de Cuba. S.A. has placed on stream its new 25,000-bpd refinery at Havana. This has increased Cuba's refining capacity to 35,700 bpd, and by this time next year that figure will be more than doubled. Esso Standard Oil Co., S.A. is presently expanding its 8700-bpd refinery at Belot to 35,000-bpd, and at Santiago de Cuba The Texas Co. is building a 20,000-bpd plant.

Southern Nitrogen Co., Inc., has begun production of its new synthetic ammonia plant at Savannah, Ga. Capacity of the plant is expected to be around 250 tons per day. Nitrogen solution output will begin this month with solid ammonia nitrate following in April. Cost of the plant was $14 million.

Union Oil Co. of California has awarded a contract to Ehrhart & Associates, Inc., for the engineering and construction of a crude topping plant at Union Oil's Oleum, Calif. refinery. The plant will process crude oil transported by Union's crude oil pipe line from San Joaquin Valley. Completion of the project is slated for the summer of 1957.

Kerr-McGee Oil Industries, Inc., has announced plans for additional refinery facilities for its refinery at Wynnewood, Okla. Plans include construction of a 5500-bpd Platformer, and a 4000-bpd Unifier, with the attendant auxiliaries.

The new facilities will enable the refinery to exceed all foreseeable requirements for high octane gasoline, but will not change the refinery's total crude throughput.

The Apache Powder Co., Benson, Ariz., is adding an ammonia synthesis plant to its explosive works at nearby Curtiss. The Girdler Co. of Louisville, Ky., has been authorized to design, engineer and start up the new facilities, which will cost approximately $1 million.

The process will employ hydrocarbon reforming operations to produce ammonia synthesis gas from natural gas, and Girdler catalysts will be used. Apache plans to place the plant in operation in the latter part of 1957.

Sinclair Oil & Gas Co. is expanding facilities at its gas products plant No. 27 near Sweetwater, Texas. Sinclair is adding the third compressor unit at its Wimberly Booster Station in Nolan county, which will boost oil-well gas handling capacity by 2.1 million cubic feet daily.

The Wimberly station gathers and boosts oil-well gas from the Sweetwater Canyon field of Nolan and Fisher counties, Texas, to the gas products plant No. 27 in Nolan county for processing.

The company also is installing the fourth compressor at the main plant. The 500-hp. unit will have a gas processing capacity of 1.8 million cubic feet.

With completion of the expansion program, the entire plant will have a processing capacity of 9 million cubic feet.

Neste OY will install a 9000-bpd Thermofor Catalytic Cracking unit at its 18,000-bpd refinery at Turku, Finland. The TCC process which was developed and licensed by Socony Mobil Oil Co., is presently in use at 20 refineries outside of the United States. Some of these have been on stream for as long as six years.

U. S. Oil & Refining Co. is building a 2500-bpd Houdriformer at Tacoma, Wash., as part of an expansion program at its refinery. The unit is scheduled to go on stream this summer.

Houdry 3-D platinum reforming catalyist will be used in the three-chamber unit. Flexibility of unit design permits processing of desulfurized virgin naphtha and thermally cracked gasoline feedstocks from Middle East and Canadian crudes. Holmes & Narver, Los Angeles, are handling engineering and construction.

Shell Oil Co. has revealed plans for a $1 million dollar expansion to its recently announced Wilmington-Dominguez refinery building program. A 200,000-pound boiler will be added to the catalytic cracking unit at the company's refinery to provide additional steam capacity for the new Platforming unit under construction. A special feature of the boiler facility is that it will convert waste gases in the catalytic cracking unit effluent to useful heat.

Additional steam demands for the multi-million dollar expansion of the Shell Chemical Corp. plant adjacent to the Wilmington-Dominguez refinery will also be met by the installation of the boiler.

The Texas Company has completed facilities at Port Arthur, Texas for the production of di-isobutylene, which is used in the production of plastics, elastomers, lubricating oil additives, and other

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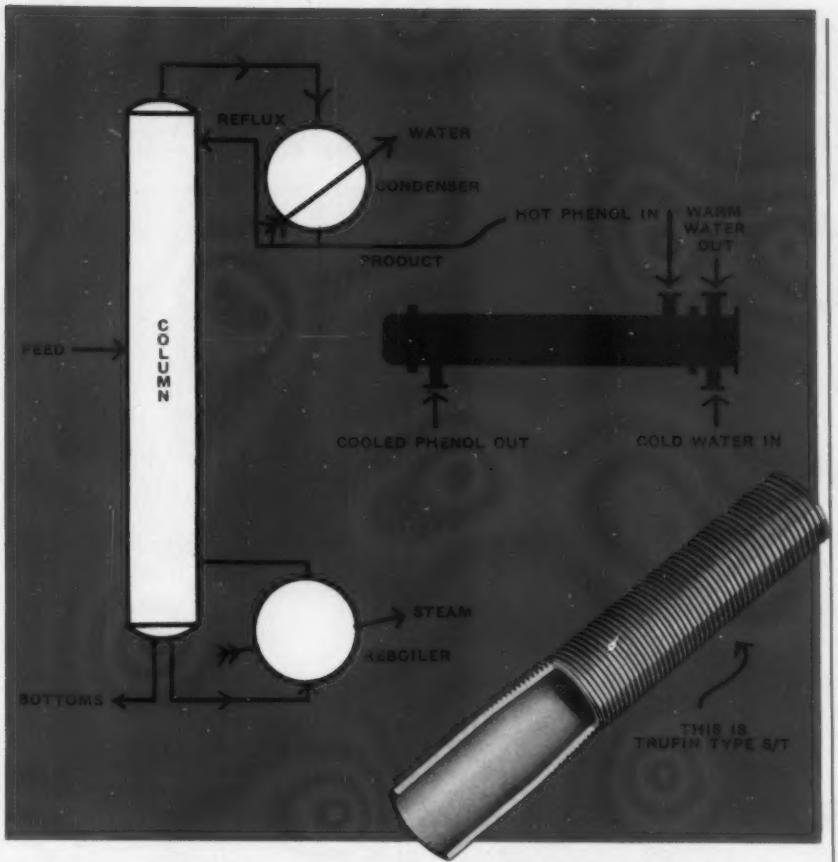

ONE TRUFIN-TUBED PHENOL COOLER REPLACES TWO PLAIN TUBE EXCHANGERS

By Ernest Dodd

Down near Louisiana's gulf coast, processing engineers at a large refinery are currently engaged in some highly interesting experiments in the field of heat transfer.

To put it bluntly, the objective of their research is to compare the performance of Wolverine Trufin® Type S/T against that of prime surface condenser tube. The results to date are proving conclusively that Trufin Type S/T offers plus advantages impossible to obtain from plain tube.

In conducting their research, the engineers are using two coolers—one tubed with prime surface tube and the other with Wolverine Trufin Type S/T—the integrally finned condenser tube. The operation involved is the cooling of phenol with water on the tube side and the phenol being cooled on the shell side.

To obtain a comparison of performance everything is the same—except the surface of the tubes. The extended surface, Trufin-tubed unit has 860 pieces of Admiralty Trufin Type S/T ¾" O.D. by 16' in length. The prime surface unit also has 860 pieces of tube of the same O.D., alloy and length.

It is in heat transfer surface, however, that a startling difference becomes apparent. The prime surface unit has a total of 2,690 square feet. In the Trufin-tubed unit the total heat transfer surface soars to 6,050 square feet—an increase of 125% (or 225% of the surface of the plain tube unit).

The Trufin-tubed cooler has been on stream for the past eight months and is presently handling the entire heat load formerly handled by the two plain tube coolers. Its record, in fact, is so good that the refinery engineers have designed Trufin into several of their forthcoming expansions.

WRITE FOR FREE BOOK

Actual installations where Wolverine Trufin is being used throughout the processing industries are described in text and drawings in the "Wolverine Trufin Process Flowsheets" Book.

In addition, this handy book also contains information about Wolverine Tube, its facilities and the specialized engineering services it offers its customers.

Processing Engineers – both experienced veterans and those just starting their careers will want to add this source of finned tube information to their reference files.

The Trufin Process Flowsheets Book is yours without cost or obligation. Write for your copy today!

CAN SUBSTITUTE TRUFIN DIRECTLY FOR PLAIN TUBE

When retubing heat exchangers or condensers, no basic equipment changes are necessary where Wolverine Trufin takes the place of prime surface tube.

During the finning process the ends of the tube are left without fins and the tube is designed so that the O.D. of the plain end is slightly larger than the O.D. over the fins. As a result, Trufin can be inserted into the bundle and rolled directly into the tube sheet in the regular manner using standard tools and normal retubing techniques.

TRUFIN INCREASES ON STREAM TIME

When working for the first time with integrally finned condenser tube, designers sometimes assume that finned tubing should be used only in a clean service.

Nothing could be farther from the truth. The compilation of actual operating data and the results of extensive pilot plant research are proving, instead, that integrally finned Wolverine Trufin actually gives better service than plain tube over longer periods of time.

Comparison tests (such as that described at the left) show that when Trufin fouls, the buildup of scale follows the profile of the fins and tube instead of preferring the valleys between the fins. Because Trufin does not present a flat, unbroken surface, there is a strong tendency for the scale to fall away—thus preventing the buildup of an impervious layer.

Wolverine Trufin available in Canada through the Unifin Tube Company, London, Ontario.

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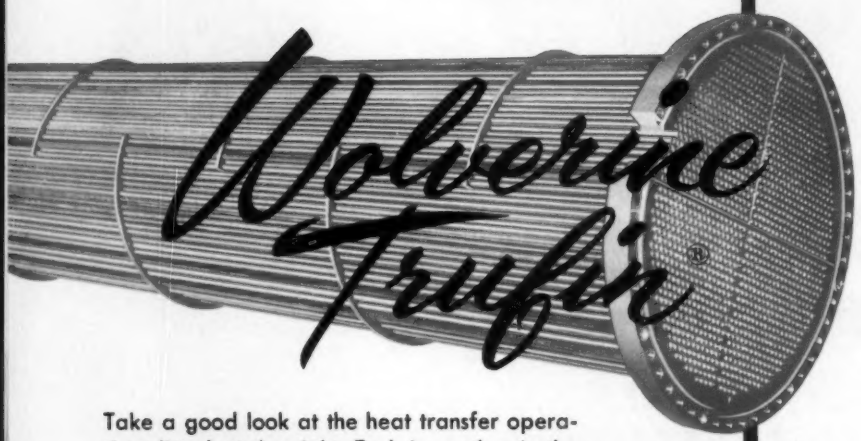
MODERN HEAT TRANSFER CALLS FOR



Take a good look at the heat transfer operations listed at the right. Each is another in the long list of applications where Wolverine Trufin—the integrally finned condenser tube—is boosting heat exchanger and condenser capacity by transferring more BTU's per foot of tube.

In recent months, this series of advertisements has described operations where Trufin has boosted capacity by as much as 70%. These are authenticated figures—proof indeed that Wolverine Trufin is the answer to modern heat transfer needs.

If you're looking for increased capacity, reduced heat transfer costs and better all-round performance, now is the time to investigate Wolverine Trufin. Send for your copy of Wolverine's new book "Comparative Heat Exchanger Costs" or let Wolverine's Field Engineering Service review your particular problem. Either way you'll be on the road to increased heat transfer efficiency.

- Asphalt heater
- Reboiler
- Atmospheric section
- Light hydrocarbon condenser
- After cooler
- Heater
- Nitrogen after cooler
- Propane condenser
- Debutanizer condenser
- Ammonia condenser
- Methyl chloride condenser
- Phenol cooler
- Ethyl chloride condenser
- Butylene condenser
- Freon condenser
- Toluene reboiler
- Iso butane condenser
- Cooler
- Oil to Oil
- Debutanizer reboiler
- Oil cooler
- Gas cooler
- Inter-cooler
- Kerosene cooler
- Oil heater
- Tank suction heater
- Stripper overhead condenser
- Amine reboiler
- Debutanizer bottoms cooler
- Alcohol cooler
- Lube oil cooler
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Who's Building...

chemical products. Di-isobutylene is manufactured by polymerizing isobutylene.

Initial capacity will be 8 million pounds annually, but provision is being made for expansion as requirements increase. Di-isobutylene will be available in tank car lots.

Completion of the di-isobutylene facilities will mark another step in Texaco's current petrochemicals expansion, which includes construction of a lubricating oil additive plant at Port Arthur and an ammonia plant at Lockport, Ill.

American Oil Co. this summer will begin construction of a gas treating and sulfur recovery plant at its Yorktown, Va. refinery. The Fluor Corporation, Ltd. are the engineers and contractors.

The facility, which is the second addition by American Oil to the original plans for the $35 million refinery, is designed to remove about 50 tons of sulfur per day.

The sulfur emerges as a liquid and is kept heated and liquefied until it can be pumped into tank cars and shipped. The hydrocarbon gases from which the sulfur is removed are piped back into the refinery and burned to provide heat for other refinery purposes.

Imperial Oil, Ltd., is considering a modernizing and expansion program for its Calgary refinery, now rated at 9200-bpd. The $17 million project would double this amount, and would add the most modern type of units to the 24-year-old plant. Imperial holds an option on 260 acres of muncipally owned land contiguous with the refinery site. Crude from Turner Valley and other Alberta fields is currently processed into motor and aviation gasoline, fuel oils and asphalt for Alberta and British Columbia markets.

British American Oil Co. has announced that The Fluor Corporation of Canada, Ltd., has been awarded a contract of more than $4 million for additional engineering, procurement, and construction of offsite facilities at B-A's Clarkson, Ont., refinery.

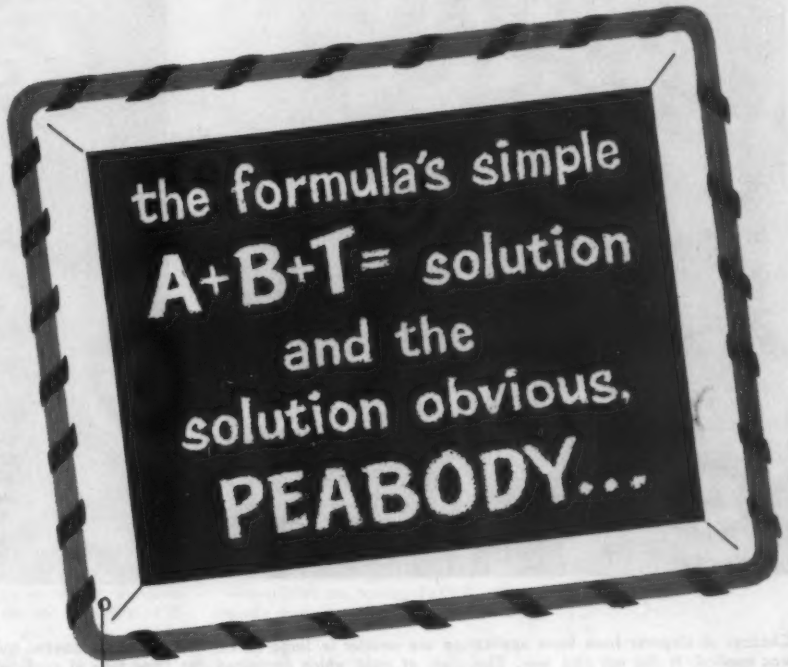
The offsite facilities will serve a new reformer and crude unit being built at the refinery. Fluor's portion of the total contract now amounts to more than $7 million.

Alaskan-Yukon Refiners & Distributors, Ltd. (formerly Shamrock Petroleum Co.) has started preliminary work on its 7500-bpd refinery in Haines, Alaska. The $6 million plant which will include a 2500-bpd thermal cracking unit is expected to be on stream sometime in 1958.

Standard Oil Co. of California is considering building a new refinery in the Pudget Sound, Washington area. Capacity of the plant will probably be somewhere between 50,000- and 60,000-bpd.

Tidewater Oil Co. has placed on stream an alkylation plant at its Delaware refinery. With a capacity of 5000-bpd, the alkylation plant is the fifth unit to go into operation at the 130,000-bpd Tidewater refinery, 15 miles south of Wilmington. The remaining units will begin operations shortly.

For dependable air heating –



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A = Air. Many process problems involving air heating require huge amounts of air. Peabody Air Heaters can—and do—handle over 250,000 SCFM. They are job engineered to your specifications for up, down, or horizontal firing!

B = BTU. These same process problems require high heat release and Peabody units offer you as much as 350,000,000 BTU/hr. in a single prefabricated furnace using a single burner.

T = Temp. Temperature sometimes has to soar—and Peabody Air Heaters offer temperatures ranging up to 2,500° F.

If you need a compact, cylindrical, air heating furnace, pressurized or unpressurized, to deliver a controlled volume of heated air, look to Peabody, the standard of efficiency throughout the world.

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FIGURE 1

FIGURE 2

Chances of slopover from foam application are smaller in large tanks. The 30-foot diameter tank at left had burned 30 minutes before foam was applied. It did not slop over. The drum at right which contained the same type of crude was allowed to burn only 20 minutes before foam was applied; yet it slopped over.

Safety and Fire Protection—Part III

How to Control Crude Oil Tank Fires

Here are the latest fire control and extinguishment methods including the author's own development—air agitation.

J. L. Risinger
Maplewood, N. J.

A LARGE CRUDE OIL tank is located about eight miles from a refinery. Water and foam are available at the farm but no personnel is available except at intervals. The tank farm is large and some of the tanks are of composition or wood roof construction and therefore not lightning proof. The tanks do not have lightning protection.

The farm is not equipped for air agitation. Should a fire occur, it will be from 1 to 2 hours before fire fighters arrive with proper fire fighting equipment. By this time, the heat wave will be from 18 to 30 inches in depth and slopover would occur if the foam were turned on.

Suppose the tank on fire is filled to capacity, or near so. *What can be done?* The following procedures are suggested:

1. The first to arrive must call the superintendent and the refinery.
2. If he arrives over 30 minutes after ignition, he should not turn on the foam but start pumping out.
3. If personnel and facilities are available, start hose streams on shell of tank above liquid level as soon as possible, allowing some water to drain very sparingly over the tank but not enough to cause slopover. Also, paint a stripe of heat detecting paint

All-welded feedwater heater for new generating station will operate at 3200 psi with inlet steam temperature of 678° F. Designed and fabricated by The Lummus Company, the unit is the first of its kind, is also the biggest heater ever built for operation at pressures above 3000 psi, having 12,710 square feet of tube surface in a single shell.

First All-Welded Feedwater Heaters Will Cut Generating Station Maintenance Costs

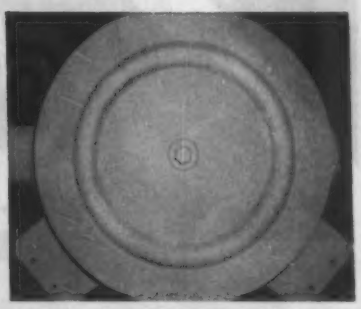
The first all-welded feedwater heaters ever built have been designed and fabricated by Lummus for the Linden Generating Station of the Public Service Electric and Gas Company of New Jersey. When completed, the installation will include 6 all-welded heaters, designed to operate at pressures well above 3000 psi, and 12 low pressure heaters which were all welded except for the tube to tube sheet joints.

In addition, Public Service has just given Lummus a contract to supply feedwater heater requirements for their new Bergen Generating Station, duplicating in design the Linden units.

Welded construction minimizes leaks in tubes, shell and head. Thus the new units are expected to reduce materially the costly maintenance and downtime associated with failure of seals in bolted and gasketed constructions.

These unique heaters are the end result of over ten years of design and experimental work by The Lummus Company with all-welded fabrication. Perhaps this pioneering can help you reduce maintenance problems, too. For more information write The Lummus Company, 385 Madison Avenue, New York 17, New York.

Ends of cupro-nickel tubes are jointed to steel tube sheet by Inco "140" Monel Ni-Cu alloy electrodes. This alloy fuses well with both tube and sheet materials, forms strong, sound joint.



Closed head shows torus ring seal which is welded to channel and cover. Gasketed joint has been eliminated to avoid possibility of leakage. Design water pressure of unit is 3600 psi.

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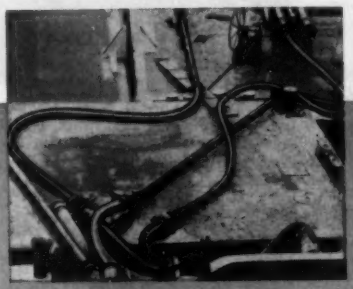


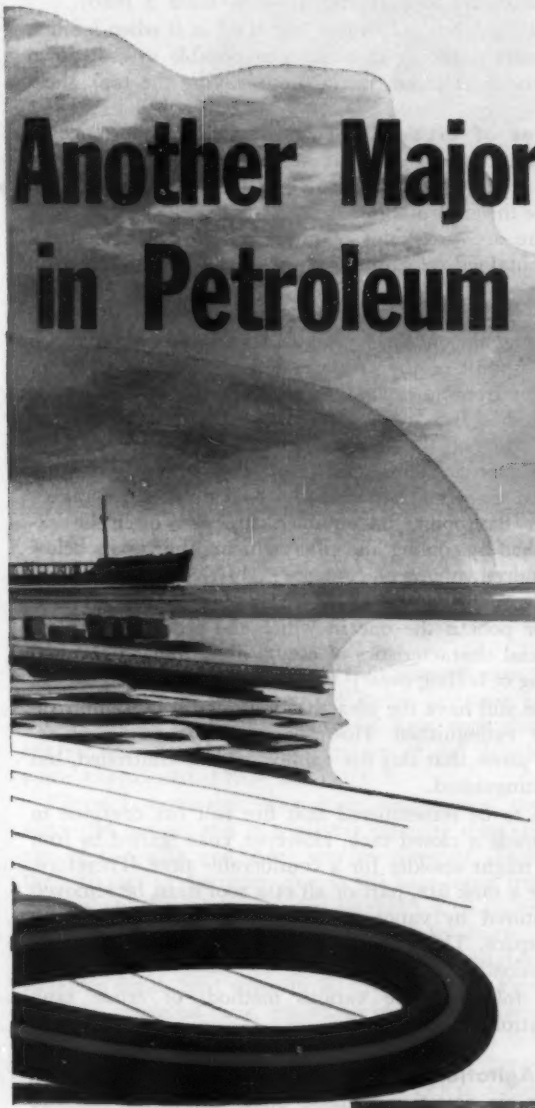
FIRST with U. S. Amazon H-1515 Oil Discharge Hose.

Flexible smooth-bore, ⅔ lighter, takes up to 200 lbs. working pressure, needs less handling gear. Make-up time is reduced and accident hazards lessened.

FIRST with U. S. Amazon H-1818 Smooth Bore O S & D Hose.

Takes up to 200 lbs. operating pressure, withstands the roughest handling, has up to 100% greater hydrostatic values, extreme flexibility. H-1818 is the only burstproof smooth-bore hose.

Another Major Achievement in Petroleum Transport Hose



Now, from U. S. Rubber, the world's pioneer oil hose manufacturer, comes new additions to its line of Amazon® petroleum dock hose. There is a hose for every requirement—dock, barge loading and general loading services — rough bore or smooth, for extra high or normal working pressures.

Each hose has qualities that cannot be found in any other make hose of similar type — qualities of easier handling, greater flexibility, higher hydrostatic value — all of which make U. S. Amazon superior to any other hose on the market.

The new, complete line of U. S. Amazon petroleum transport hose is obtainable at any of the 28 District Sales Offices, or by contacting us at Rockefeller Center, New York 20, N. Y. In Canada, Dominion Rubber Co., Ltd.

AND NOW
TO COMPLETE THIS MOST UP-TO-DATE LINE OF DOCK HOSE, U.S. RUBBER IS ONCE AGAIN...

FIRST with U. S. Amazon H-2020 Rough Bore Oil Suction & Discharge Hose.
For 200 lbs. working pressure. Both inner and outer supporting wires double the hydrostatic values. Also suitable for hot asphalt and heated oils. Absolutely burstproof.

FIRST with U. S. Amazon H-2424 Rough Bore Wire Cord O S & D Hose.
For 150 lbs. working pressure, contains inner supporting wire in bore; specially designed carcass has each wire imbedded in its own neoprene layer. Conducts any petroleum product. Very flexible.

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United States Rubber

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on tank from above liquid level to the bottom.

4. When ready to apply foam, reverse and pump in at the highest rate possible until flames come down or for at least three minutes. Even if complete control is not established, the heat wave may be rolled into the quantity of oil so that foam can be applied without slopover.
5. Clear personnel from near shell of tank and start foam. As foam starts, gradually cut down on pumping rate and then cut out pumping entirely. This will allow foam to spread uniformly.
6. If pumping out is through, swing line, lower suction to bottom of tank when pumping out and if suction becomes blocked, pump in to open it up. When pumping in to agitate, raise suction to within about one foot of surface for best results.
7. If pumping-in rate is low and a portable air compressor is used (but not of capacity to do the entire job), use air as auxiliary to pumping in, through the same line, water drawoff or other connection.
8. If tank is equipped with mixers, use them alone if pumping in is not possible. Otherwise, use them as auxiliary to pumping in when foam is ready.
9. If tank has only a few feet of oil in it when ignited, start pumping in as soon as possible to cool down the heat input and assist in saving the tank shell.

Proper Crude Tank Fire Protection Calls for Close Adherence to the Following Seven "Rules-of-Thumb":

1. Before the fire occurs, know the characteristics of the crude oil stored in your tanks and especially those which might become ignited—what facilities are available to control and extinguish the fire.

2. If foam is to be used to extinguish a cone roof crude tank fire:

   a. Apply at required rate before heat wave of slopover depth has been established.
   b. If slopover heat wave depth has been established, cool it out or stir it in before applying foam. It can be stirred in by air agitation, pumped in or a combintaion of both, at least until the heat wave has reached a one-fourth depth of the oil. It may be best to withhold agitation until just prior to application of foam especially if the crude oil has a low heat wave rate.

3. At all times when fighting a crude oil tank fire, use precautions against burns from slopover or boilover. Plan procedure carefully and deliberately.

4. In smaller tanks where non-water base agent is to be used to extinguish the fire, heat wave characteristics are of no consequence.

5. In the case of small tanks where foam will not arrive for a considerable length of time, plan to extinguish with dry chemicals or other agent that does not have a water base.

6. Make use of heat detecting paint to determine the depth of the heat wave on crude oil tanks that have burned for a period of time from open surfaces before agitating the tank or applying foam.

7. If tank containing crude oil with heat wave establishing characteristics has burned from open surface for a period of thirty minutes, assume that the heat wave is of slopover depth.

Types of Crude Oil Fires—Of first importance to control and extinguishment is knowing the characteristics of the crude oil at a particular location. Simple tests will provide this information.

There are two kinds of crude oil fires: Uncontained and contained oil and gas fires — and the contained oil fire.

Uncontained crude oil fires are fought in the same manner as uncontained product fires, in accordance with the flashpoint of the crude. These running, spewing, or dropping from an elevation low flashpoint fires have to be extinguished by:

- Cutting off the source of flame.
- And/or reducing the air in the vapor-air mixture and throwing it out of the burning mixture ratio.

High flashpoint, uncontained fire can often be extinguished by cooling and thus reducing the vapors below the required volume percentage.

The *contained* fire in which the oil is trapped in a tank or pool is the one in which the crude oil displays its special characteristics of establishing a heat wave and slopping or boiling over.

Some still have the idea that a crude oil tank fire cannot be extinguished. However, extensive tests and research prove that this fire cannot only be controlled, but also extinguished.

It is to be remembered that fire will not continue to burn inside a closed tank. However, coke ignited by iron sulfide might smolder for a considerable time. Therefore, to have a tank fire, part or all of a roof must be removed or ruptured by vapor pressure or an explosion in the vapor space. This enables the entrance of air to support combustion.

The following are various methods of crude tank fire control:

Air Agitation—In the case of high flashpoint crude oil, the air agitation method alone will extinguish the fire if applied before the heat wave is of sufficient depth so that when it is stirred in, the temperature of the oil is raised to above its flashpoint.

Air agitation alone cannot be depended upon to extinguish a low flashpoint crude oil tank fire. In some tests however, crude oils with a low flashpoint but with a vapor pressure below 1 pound per square inch were extinguished by air agitation alone before a heat wave had been established.

Use of Foam Without Slopover—If a large crude oil tank fire can be attacked within twenty to thirty minutes after ignition, depending upon the heat wave rate of the crude oil, there is not much danger of foam causing a slopover. This is a special case in which it is important to know in advance the heat wave rate of the oil.

In a recent test, a 30-foot diameter, 30-foot high tank filled to 25 feet in depth with Mid-Continent crude oil had burned for 30 minutes before the foam was applied. This oil with a 30 percent gasoline content and vapor

FIGURE 3

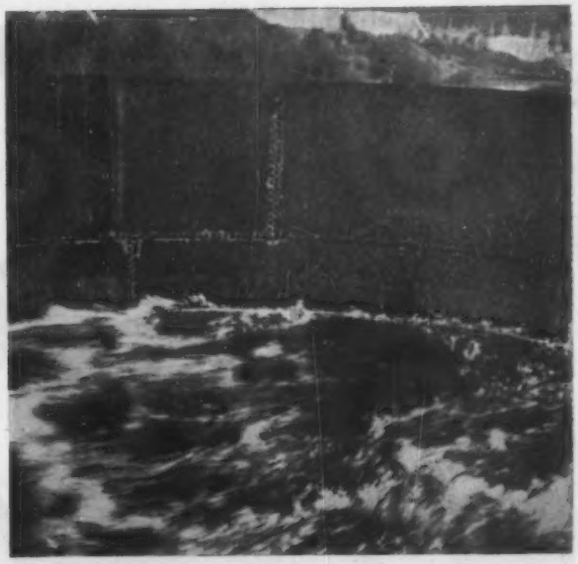


FIGURE 4

WITHOUT AIR AGITATION. Thirty-foot diameter tank at left is shown burning without air agitation. WITH AIR AGITATION. Picture at right was taken from top platform of tank at left, thus showing reduction of flames by agitation when 80 cubic feet of air per minute were injected through line terminating at bottom center of the tank.

pressure of above 5 psi had a rapid burn-off rate, but a heat wave rate of only about 14 inches per hour at first.

Due to the excessive quantity of light ends that had not yet burned off, the temperature of the 7-inch heat wave was calculated to be about 300 F.

Figure 1 shows that when foam was applied, the heat wave did not expand to a greater capacity than the outage of the tank and there was no slopover. Tanks less than 20 feet in diameter, due to the heat input from the shell above liquid level, may establish a slopover heat wave in less time than a larger tank. In drums, crude oils with average heat wave rates will have established a slopover depth heat wave in 20 minutes. (See Figure 2)

If the crude oil tank, regardless of size, has burned for twenty minutes or more, a quick stroke of heat detecting paint will tell how deep the heat wave has penetrated. Nine inches of heat wave in any container provides great possibility of slopover depending upon the nearness of the surface of the oil to the top of the tank and the viscosity of the oil.

It is difficult to establish a safe heat wave depth prior to which foam can be applied without slopover. This would depend upon the height of shell intact above liquid level, viscosity of the oil and the rate of foam application. However, where crude oil tank fires can be attacked with foam within a short time after ignition, they can be extinguished without slopover.

When fighting a crude oil tank fire with foam and if water stream is available, give it a shot at one spot near one side of the shell. If mild slopover occurs, delay application of foam until heat wave can be cooled or dissipated. If foam is applied before an appreciable heat wave is established, air agitation will reduce the flames and the amount of foam required to extinguish the fire (See Figures 3 and 4).

How to Reduce Heat Waves — There are several ways to break up a heat wave of slopover depth and thus prevent a slopover when foam or water is applied.

The old method of cooling out a heat wave before application of foam works part of the time. This method consists of raining water into the heat wave by use of hose nozzle, thus causing a mild slopover which is extinguished with the same hose. This operation is continued until it is considered safe to apply foam. The method takes a long time and usually fails due to impatience and putting foam on too soon.

If water is available it should be applied to the shell above the liquid level as soon as possible to prevent it from buckling. Usually, after about ten minutes burning in a tank over 20 feet in diameter and with a 4 or 5-foot free-board, the shell will start to buckle.

Air agitation will reduce the heat wave by stirring it into the quantity of oil. This method is effective up to the time the heat wave has progressed to one-fourth the depth of the oil. Beyond this depth, stirring the heat wave may raise the temperature of the oil above the boiling point of water. In this case (if there is water in the bottom of the tank) a boilover will begin.

If there is no water in the bottom of the tank and the oil temperature is raised above the boiling point of water, a mild slopover may occur when the foam is applied. If good control can be established, the flames will be brought down and less foam required.

In Figure 5 the small crude oil tank has burned to a heat wave depth of approximately one-fourth the depth of the tank so that when foam is applied, the tank slops over. In Figure 6 the same size tank containing the same kind of crude oil has been allowed to burn until the heat wave depth is approximately one-fourth the depth of the oil. But in this case the oil has been agitated with air. When foam is applied no slopover occurs.

Use of Gases and Cold Oil — It is to be kept in mind that in the method of air agitation, air performs

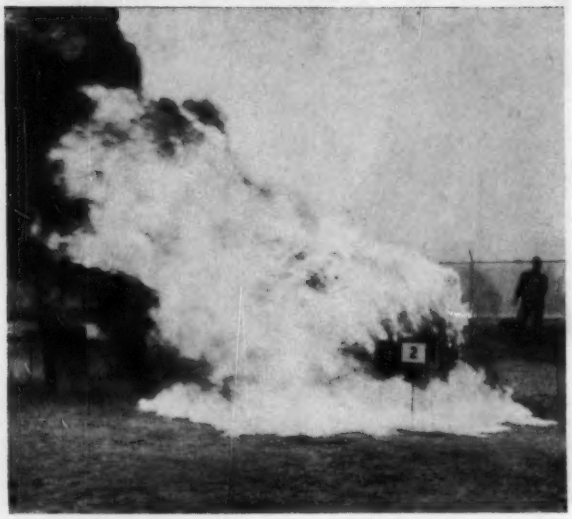


FIGURE 5

FIGURE 6

Small crude oil tank at left has burned to a heat wave depth of about one-fourth the depth of the tank. When foam was applied the tank slopped over. The same size tank at right which contained the same kind of crude oil and the same depth of heat wave was agitated with air. It did not slop over when foam was applied.

the function only of rolling the cold oil to the surface. Inert gas and even flammable dry gas has been used successfully in tests to perform the same function. Flammable gas, such as light field gas, can be used but caution should be taken not to use a gas that is simply absorbed by the oil and thus adds more light ends.

A few small tests have been run using the pumping of the same oil, circulating and thus stirring the oil. If sufficient pumping in rate is available, cold oil can be rolled to the surface and may effectively stir in and cool a heat wave of greater depth than can be handled with air agitation.

Since but few tests have been made on this method, a detailed description of one example is presented here:

In this test, the tank was 5 feet in diameter and 57 inches high. The tank was filled to within 11 inches of the top with a sour crude mix. This crude had flashpoint below 0 F., an initial boiling point of 146, a vapor pressure above five pounds per square inch and an API gravity of 31.5. Although its final boiling point was 900 F., the quantity of lighter ends was in large proportion to the total mixture. Distillation was as follows:

IPP	—	146 F.
10%	—	228 F.
20%	—	308 F.
30%	—	388 F.
40%	—	488 F.
50%	—	594 F.
59%	—	650 F.

Plans were to burn the tank to a one-fourth depth of heat wave, circulate the oil out of the bottom and back into the tank to agitate the heat wave into the total contents of the oil.

After an hour's burning, it was observed that the burn-off was about ten inches. The heat wave had traveled a distance of 18 inches below the liquid level, or to approximately 3/8 of the depth of the oil. It was calculated that only part of the light ends were removed and therefore the heat wave was about 300 degrees temperature so that when stirred in, the temperature of the total quantity of oil would not be over 195 F.

At this time, the circulating pump was started. No attempt was made to greatly reduce the flames, but only to stir in the heat wave. Due to the remaining light ends, foam had to be applied at a fast rate to extinguish the fire. Although there was a small amount of froth at the surface, no slopover occurred.

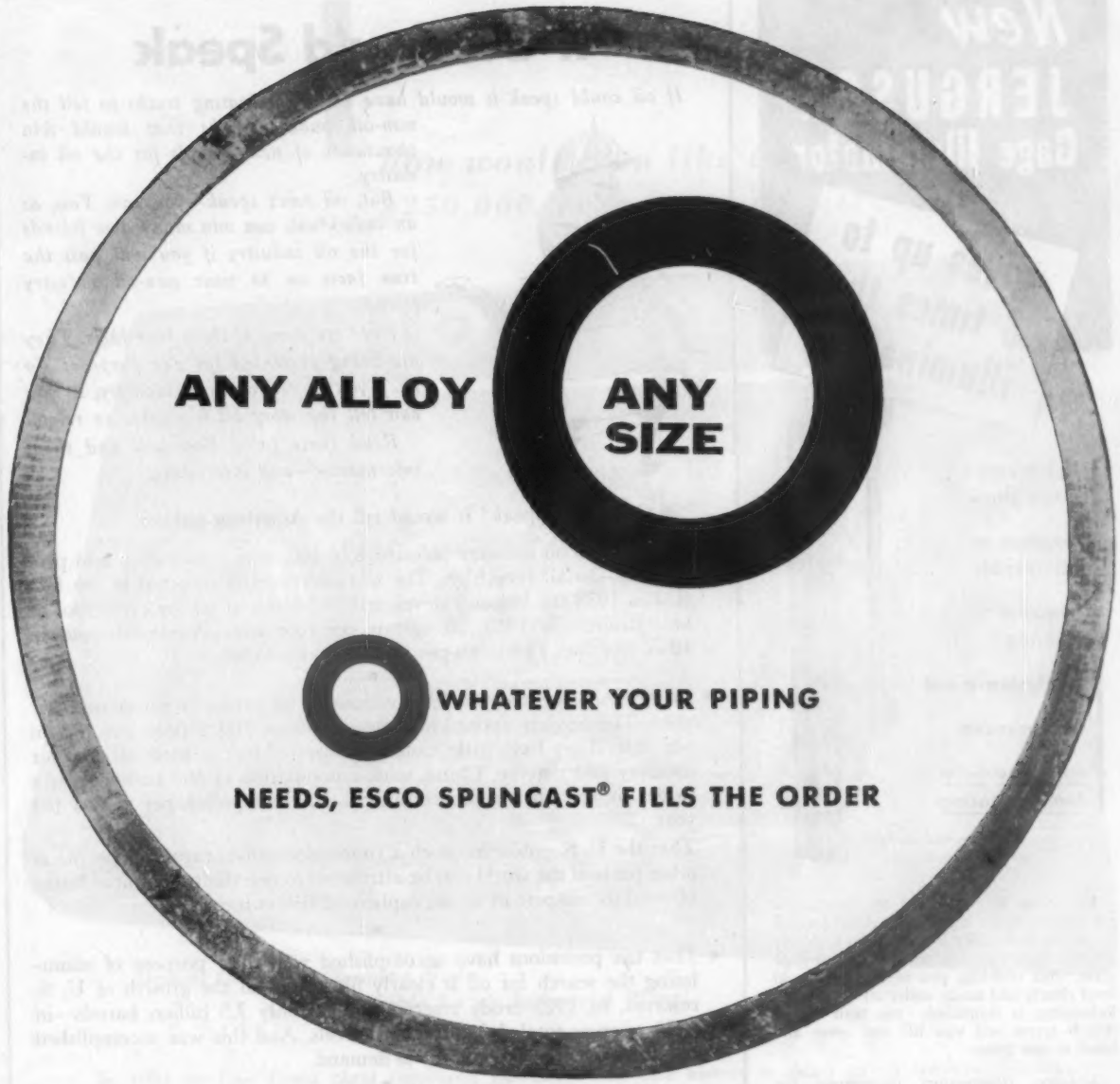
Temperature Is Important — In addition to facts learned about the new method, the significance of the temperature of the heat wave was emphasized. If the light ends had been completely burned away or the oil had contained but few or none of them, the temperature of the crude oil would have been raised to above the boiling point of water and a slopover would likely have occurred when foam was applied.

There are other unexplored methods of extinguishing crude oil tank fires. For example, suppose there is nothing available except water and the tank has burned for a long time. In this case it may be possible to use hose streams to cool and cause some froth but yet not enough to cause a violent slop. The fire may be extinguished with judicious use of water stream alone. This has been done on small tests.

It is well to consider all of the methods available for extinguishment of crude oil fires. However, in the final analysis, the best way to extinguish fires is to prevent them and the best way to prevent them is to store crude oil in all steel, gas-tight, adequately vented, cone roof tanks or correct floating roof tanks. Then maintain the tanks properly.

If this is done and certain minor precautions are observed with respect to such items as iron sulfide, the problems of fighting crude oil tank fires will become practically nil.

Part 4 will appear in the March issue of PETROLEUM REFINER



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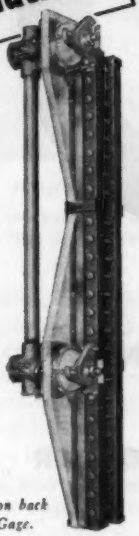

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If Oil Could Speak

If oil could speak it would have many fascinating truths to tell the non-oil public—truths that would win thousands of new friends for the oil industry.

But, oil can't speak—you can. You, as an individual, can win many new friends for the oil industry if you will pass the true facts on to your non-oil industry friends.

Here are some of those true facts. They are being presented for one purpose: To keep you posted on your industry, so you can tell the story oil is unable to relate.

Read these facts. You will find them informative—and interesting.

"If Oil Could Speak" it would tell the American public:

- In 1956, the oil industry invested $3.6 billion in exploration and production—an all time high. The increased cost is reflected in the fact that in 1938 the industry developed 34 barrels of oil for every foot of hole drilled—in 1945, 20 barrels per foot were developed—and in 1955, less than 13 barrels per foot were developed.

—•—

- In the U. S. we consume 815 gallons of oil products per person per year. The Soviets appear to consume about 100 gallons per person per year. They have little motor transport. Most of their oil goes for industry and defense. China, with a population of 580 million, seems to get by on a petroleum consumption of one gallon per person per year.

  That the U. S. public has such a tremendous advantage over people in other parts of the world can be attributed to one thing—an oil industry allowed to compete in an atmosphere of free enterprise.

—•—

- That tax provisions have accomplished well their purpose of stimulating the search for oil is clearly illustrated in the growth of U. S. reserves. In 1925 crude reserves totaled only 7.5 billion barrels—in 1955 reserves totaled 29.6 billion barrels. And this was accomplished despite a phenomenal growth in demand.

—•—

- No one knows for sure the ultimate discovery potential in the U. S. However, one estimate in 1948 fixed the amount yet to be discovered at 54 billion barrels. If that were correct, the discoverable amount is now down to less than 40 billion barrels, due to discoveries since 1948.

—•—

- Every incentive must be given for the oil industry to develop new reserves. Reason: The ratio of proved reserves to annual production for the past 30 years has been averaging about 12.5. If we assume such a ratio is comfortable, then we must have proved reserves of about 62.5 billion barrels by 1975 (compared with 29.6 billion barrels Jan. 1, 1955). It will be necessary to have new discoveries and developments amounting to about 5 billion barrels per year on the average for the next two decades just to be as relatively well off as we are right now. Yet the largest amount ever produced from new discoveries and new developments in any one year was 5.138 billion barrels in 1951.

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Remember: Oil can't speak—you can. Only you can give the non-oil public the true facts about your oil industry.

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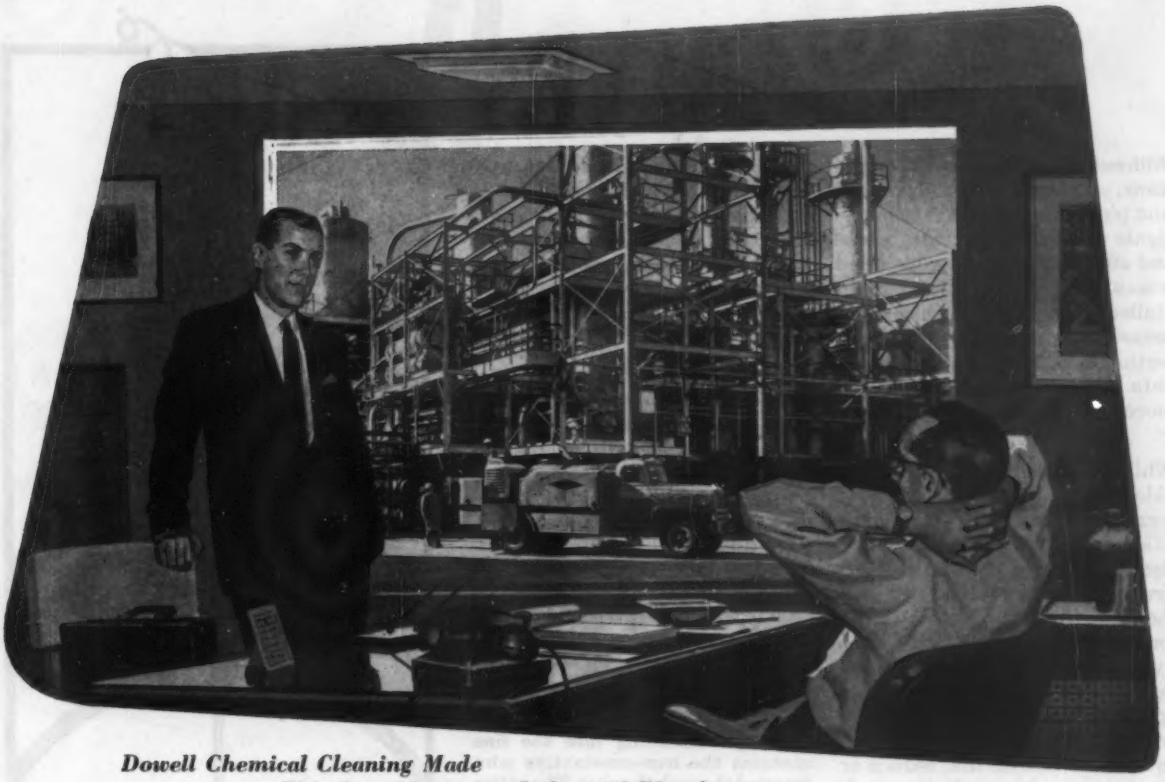

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While coupons continuously provide means of recording rate of corrosion, samplers permit periodic analysis of possible causes, thermocouples contribute desired temperature readings and the hydrogen probe helps to determine the concentration of free hydrogen present. With such information at hand, intelligent application of measures for control can be made to prolong equipment service life, reduce or eliminate product pollution and, consequently, protect important capital investment. In many cases, product quality can be more easily maintained.

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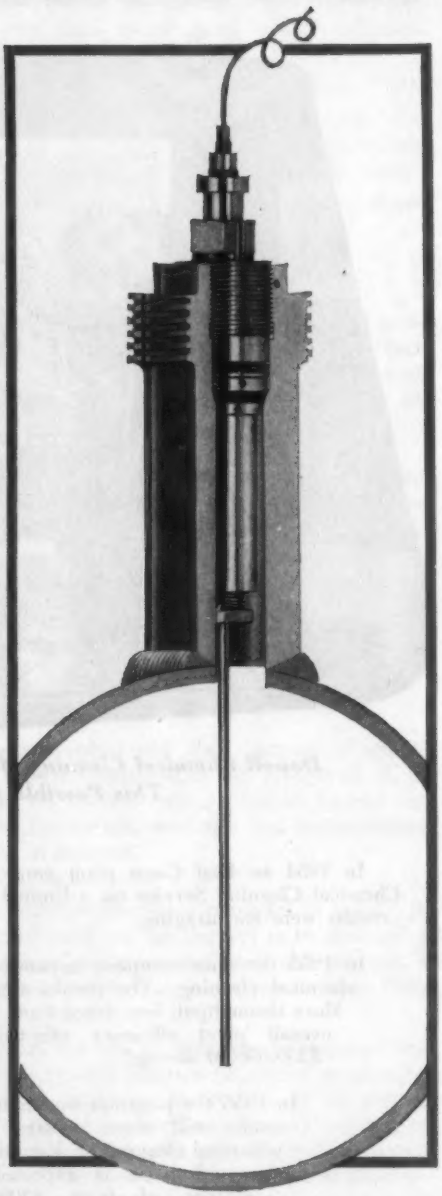

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8 Ways to Save Time

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Ernest W. Fair
Boulder, Colorado

REMOVAL OF TIME consuming factors from executive planning is one of the major steps toward efficient management. This not only makes each task less exacting and reduces nervous strain on the individual, but builds up extra moments in every day for none-routine work.

Here are eight suggestions taken from a study of methods used to remove time-consuming chores from daily routines. Only those which may be adapted to any refinery executive's job, whether the office be large or small, are presented.

1. Plan for Your Subordinates—Practically every executive whose routines were studied has found that careful planning of the activities of his subordinates, as well as his own, greatly contributes to more freedom in his time. Where such planning is left to the subordinate entirely, considerable time must be directed to readjusting such activities, making corrections and coordinating work that has already been done by these individuals.

It is too easy for each subordinate to branch off with individual ideas of his own and onto widely varying tangents unless the top executive lays down a definite plan for him to follow and continue such planning from week to week.

2. Keep Your Planning Flexible—It is important that all executive planning be kept flexible enough to

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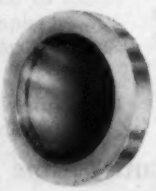

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meet changing conditions. A number of surveys indicate that where executives set down a hard-and-fast rule they invariably must find a good many hours in their daily schedule to make adjustments which would not have been necessary had a greater degree of flexibility been present in routine planning.

During the past year there were many changes in business procedures of all kinds—and there are many more to come. In one area alone—government regulations as they affect each individual's executive decisions—there will be many such changes for months ahead. Where routines are rigid and fixed it will be found that such changing conditions create numerous time-consuming periods during every business week.

3. Plan Simply. Planning so that explanations to others are easy, is vitally necessary today. Never assume that any subordinate possesses so complete a knowledge and experience as to make explanations unnecessary. Where this sort of procedure is followed the executive has an endless series of time-consuming corrections and explanations to make; explanations which take up far more time than had the explanations been made initially.

The simple and direct approach is always easiest to present, surer of making the point, and guaranteed to accomplish its purpose with a minimum use of executive time.

Making such explanation easy can give every executive from 3 to 10 extra hours in each week. It helps to reduce the need for corrective steps, relieves any burden of uncertaintity he may have, and secures much more effective production from all such subordinates.

4. Improve Subordinates' Skills—Developing subordinate skills so that they can meet one's most ambitious plans is another advisable step in reducing time consuming chores from executive planning. The junior executive and staff employe alike have to be kept as aware of the times as the chief executive of any firm.

The attention the executive gives to developing such subordinate skills has always been amply repaid in reduction of his own load in the business. Such efforts are usually a continuing process rather than an allotment of a certain period each week for that purpose, although the latter procedure has been most effective in many business organizations.

5. Let Subordinates Think for Themselves—No executive can be expected to carry the load of detail planning for each of his subordinates; when he does so he is performing a time-consuming routine that is definitely not a part of his job. Where an individual lacks the ability to successfully handle such detail planning of his job he or she should be replaced by an individual who can.

In many instances executives take on such chores because of a lack of faith in the people who work under them. Many times such lack of faith has no real basis, but is entirely in the executive's mind. Given the opportunity, most subordinates can handle routine detail chores of their jobs quite satisfactorily. Where tests show that they cannot the executive had

Remove time consumers from your daily routine and you're well on the way toward efficient management. Here are eight "rules of thumb" that will save you countless hours.

1. **Plan for your subordinates.**
2. **Keep your planning flexible.**
3. **Plan simply.**
4. **Improve subordinates' skills.**
5. **Let subordinates think for themselves.**
6. **Give assignments to the right people.**
7. **Stress "long range" planning.**
8. **Use other people's ideas.**

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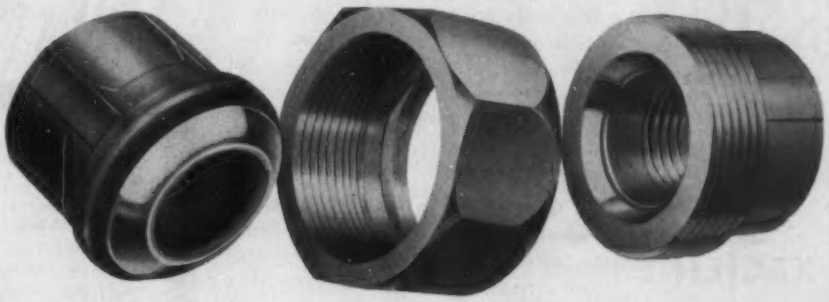

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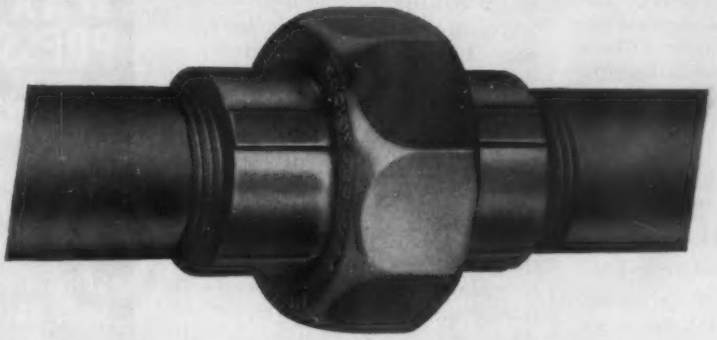

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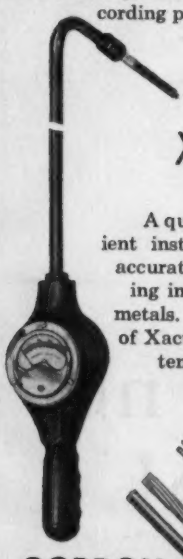

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As Management Sees It . . .

best make an investigation to discover the reasons then and there, and either take steps to correct the situation, or arrange shifts among staff personnel where each individual will be performing the tasks best suited to his or her background and experience.

6. Give Assignments to Right People—Another great time consumer in the average executives' routine day is in placing functions that he should be doing onto the backs of his subordinates. Wherever this is done a spirit of resentment arises which contributes little if anything to a good working spirit in the organization. It also hands assignments to people on the staff insufficiently trained or without adequate background to handle such problems and therefore results in kick backs for correction on the executive's desk in the long run.

Little time is saved on any executive's job by detouring such functions to subordinates which he can handle in half the time himself. He not only wastes the time of such subordinates (for they could accomplish more at the regular tasks for which they are best skilled) but adds to his own problems in tieing up the loose ends afterwards.

7. Stress "Long Range" Planning—Direct all planning on a long range rather than a short range basis. If you can establish the procedure of a given step to cover a six month period during one "sitting" time always works to your advantage over a routine which calls for six seperate plannings to cover the same area. Many surveys have found that the greatest time-killer of any executive's business day is in the accomplishment of chores which could have been anticipated or covered by a long range plan.

8. Use Other People's Ideas—Finally, many executives are finding that plans built on suggestions of others above and below them in the company organization, materially reduce the amount of their own time required to handle many chores. Using the ideas of others successfully has always been one of the marks of a good executive. It is an assured method of getting more accomplished during any given work day and obtaining the maximum use from his own time. ##

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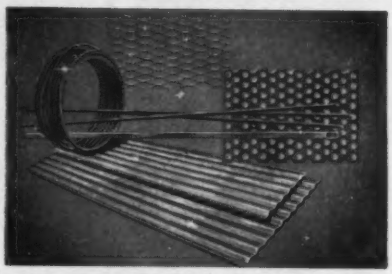

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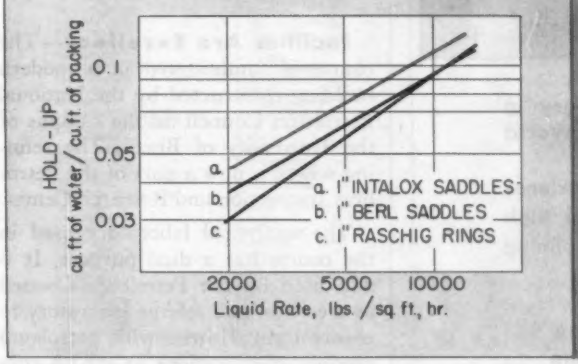
As a result it is possible with Intalox saddles to have a higher liquid hold-up than with other packings yet still retain the low pressure drop characteristics of Intalox since the higher liquid hold-up results from a greater wetted-surface-area rather than from liquid-filled voids.

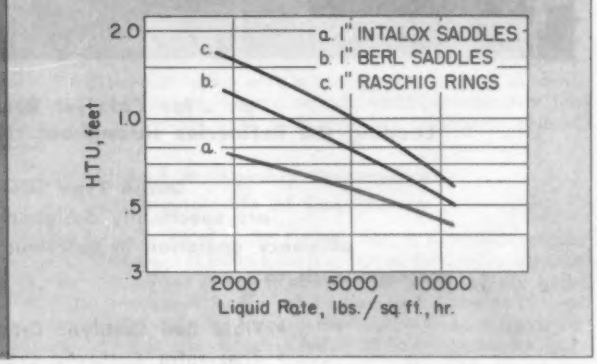
This ability to give higher liquid rates without flooding is reflected in substantially better mass transfer performance.

Fig. 1—HOLD-UP DATA



Higher liquid hold-up of Intalox Saddles reflects the better accessibility of the packing surface to liquid, thus greater wetted-surface area. Voids remain open, pressure drop low.

Fig. 2—HTU DATA



The capacity data shown are typical for a system where both gas and liquid film resistances are involved. Lower HTU values mean shorter towers, less pressure drop and reduced initial investments.

Write for this free booklet:

Bulletin S29-R gives full technical data on Intalox Saddles, performance charts, typical problems and solutions. Address: Dept. PR-357 U. S. Stoneware, Akron 9, Ohio.

U. S. STONEWARE

AKRON 9, OHIO

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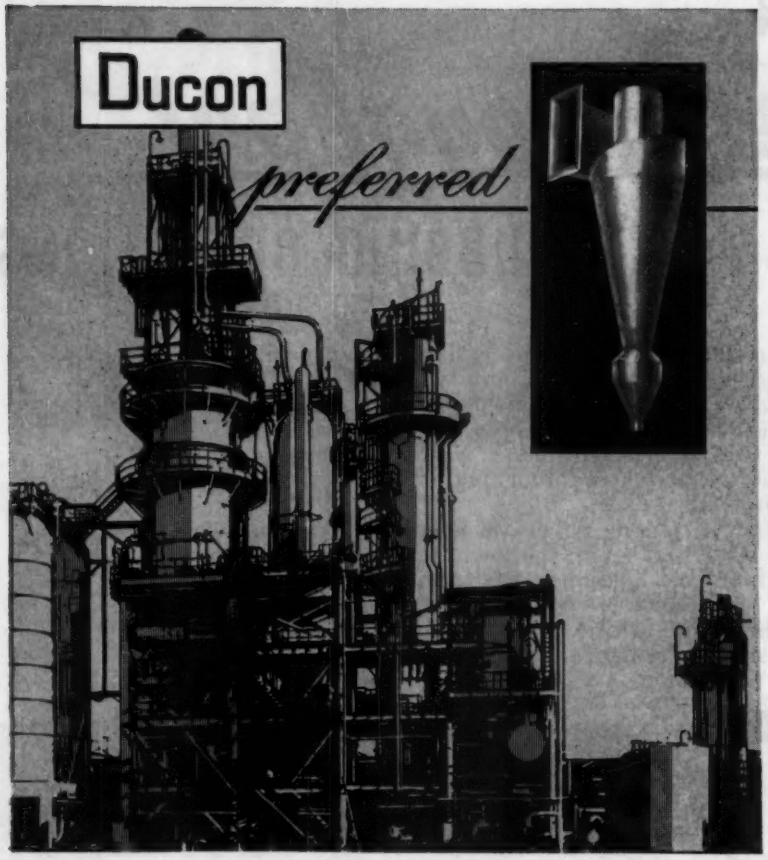

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Brazilian Refinery School

Continued from Page 142

leum products are run in the laboratory. This is followed by a special course in petroleum evaluation in which the Brazilian crudes are studied. With Brazil's exploration expanding rapidly, some of the crudes are evaluated for the first time by the students in this course.

Students are also taught how to be good supervisors and managers. Courses include methods of job-training, human relations, refinery organizations, conference procedures, leadership and effective communication. After conference procedure has been introduced it is used by the professors and students to discuss such topics as order giving, observation of safety practice, case problems from industry, etc.

To round out the course, speakers from the petroleum industry are asked to discuss their specialties. Whenever an expert from outside of Brazil visits Rio de Janeiro, he will probably find himself leading a two hour seminar at the school.

Facilities Are Excellent—The course is administered in a modern building constructed by the National Petroleum Council on the campus of the University of Brazil. The refining school is now a part of the Petrobras Instruction and Research Center.

The analytical laboratory used in the course has a dual purpose. It is also used by the Petroleum Council as a control and referee laboratory to ensure compliance with petroleum product specifications as set by government regulation. In addition, a distillation laboratory equipped with a Podbielniak column, TBP columns, and an York-Schiebel extraction column is used for training and will later be used for research.

The main laboratory is the two floor unit operation laboratory. Work is done with centrifugal and reciprocating pumps, condensers, reboilers, heat exchangers; orifices, and level, temperature, flow, and pressure control instruments. The different units are piped up in such a manner that they can be employed separately or as an integrated unit. Perhaps the finest teaching aid is the distillation pilot plant. It is a six-inch stainless steel 24-plate bubble cap column

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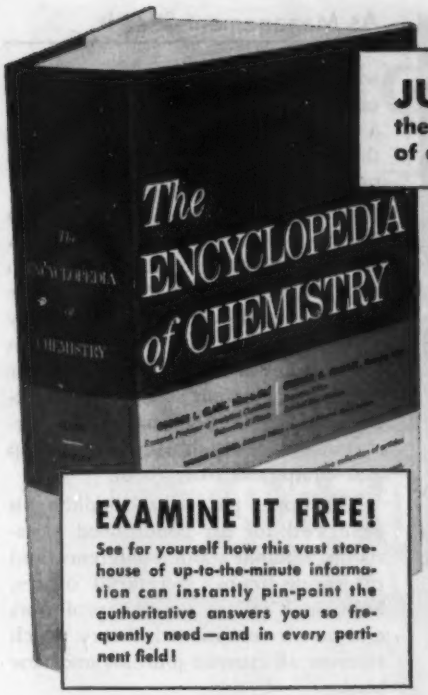

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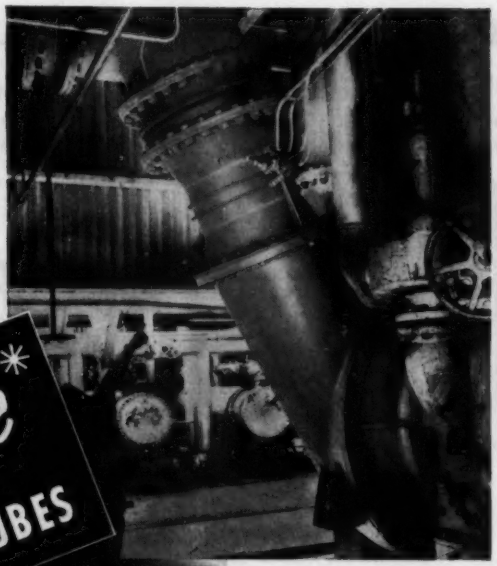

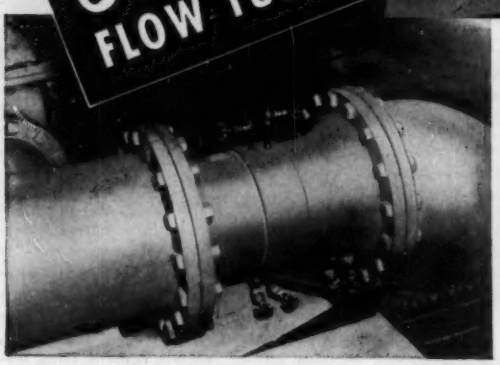

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which can be operated continuously or batch. Students are provided with a full 8-hour day in which to bring the unit on stream and to make a previously specified product.

Serving all these laboratories is a 15-horsepower boiler and a 150 KVA power transformer. The operation and maintenance of the boiler are part of the duties of the laboratory student groups. The building has a sound-proof air-conditioned room for motor and aviation knock engine testing, sample store room with refrigerator and ice machine, machine shop and equipment store room.

The upper part of the building is reserved for air-conditioned classrooms, seminar room, conference and projecting room, secretarial offices, individual offices for the professors and an air-conditioned library which receives all current journals and new books.

Future Plans—The achievements of the first four graduating classes in the petroleum industry have guaranteed the future of the refining course. The class of 1956-57 is double those of previous years. As the graduates gain experience in the refineries they are often brought back to teach courses.

In June, 1957 an 18 month post graduate course in geology will begin in Bahia with the cooperation of the University of Bahia. Foreign professors will be brought to Brazil to organize the courses and laboratories which will train engineers in petroleum geology. Field courses are already being conducted in drilling, geophysics and field geology.

Job-training schools will also be formed in the refineries and cities nearby. These schools will supply the technicians such as welders, pushers, pumpers, maintenance men, etc., which are so necessary to an industrially growing country.

The professors of the refinery school will be encouraged to do research and development studies. They will act as consultants under the chief of a research division. It is not difficult to foresee that this center will grow into the Brazilian Petroleum Institute. Plans have already been made to achieve this end. ##

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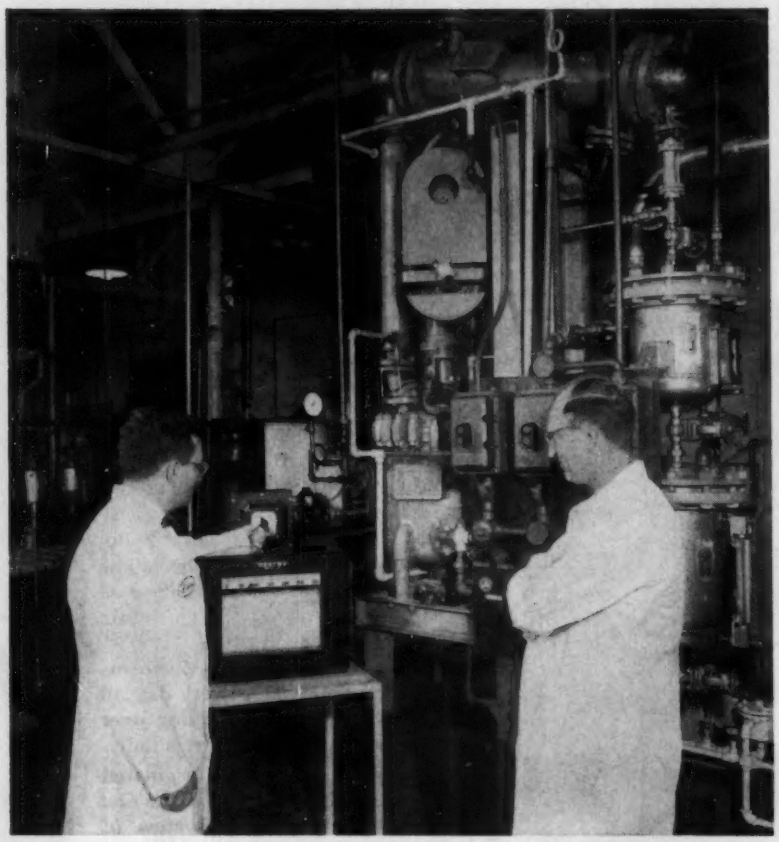

Pilot Plant Spans Pharmaceutical Operations—Almost any operation in pharmaceutical manufacture can be performed in this new 4 x 9 x 2½-ft. pilot plant unit designed for Lakeside Laboratories, Milwaukee, by Pfaudler. It can reflux, react, distill and handle quickly a host of functions. High-vacuum distillation is done at as low as 50 microns Hg absolute pressure.

Unusual pilot plant assembly steps up Lakeside's synthetic work

"Virtually all pilot plant operations in pharmaceutical chemistry can be performed in a single new compact assembly specially designed for Lakeside Laboratories, Inc.," states Joseph N. Jacques, plant engineer.

The assembly, part of the expanding synthetic chemistry division, was made to Lakeside specifications by Pfaudler. It requires a floor space of only 4 feet by 9 feet by 30 inches.

It can reflux, react, distill and handle quickly a host of physical and chemical functions. The new unit is particularly noteworthy because high vacuum distillations are achieved at as low as 50 microns Hg absolute pressure.

Made entirely of Type 316 stainless steel, it will handle most of the organics used in Lakeside's products. It is presently used for distilling N-Ethyl-3-Hydroxypiperidine.

All of the initial synthetic work is concentrated on the production of antispasmodics, produced under the trade names of "Dactil," "Piptal," and "Cantil." The staff has found the equipment fast, versatile and easy to manipulate, Mr. Jacques said. The unit can be used for small-scale pilot plant operations as well as full-scale production.

New low-cost corrosion-resistant "Chemstors" get wide usage

Since the introduction of the low-cost Pfaudler glassed steel "Chemstor," companies in various industries have found it the answer for storing corrosive liquids.

A quick analysis of usage reveals successful handling of such products as chlorine dioxide, chlorosulphonic acid, polyvinyls, hydrochloric, nitric, and sulphuric acids in various concentrations, distilled and potable water and a host of inorganics which were not specified. Pfaudler glass prevents product contamination and assures easy cleaning.

"Chemstors" are available in both horizontal and vertical design. Sizes range from 750 to 35,000 gallons and *cost as low as 25¢ per gallon*, depending, of course, on size and service requirements.

Flanged nozzles, in sizes from 3″

Beginning of "Chemstor" tank farm. The more of these low-cost glassed steel storage tanks you use, the greater your product protection and ease of cleaning.

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Corrosioneering News

Quick facts about services and equipment available to help you reduce corrosion and processing costs.

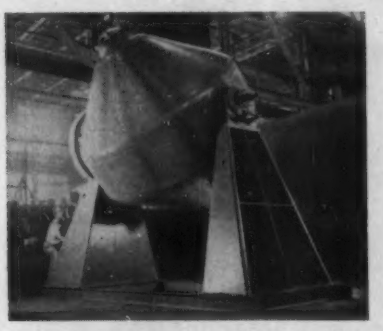
I.D. up, are provided as required. The standard manhole is in the shell at the top of horizontal tanks and in top head of verticals. Both are 12" x 16". The manhole cover is flat and glassed on the inside.

You can drastically reduce your storage costs with these dependable Pfaudler "Chemstors" because of: (1) low initial cost, (2) greater product protection, (3) easier cleaning. Bulletin 918 gives you all the facts.

Amazing test results with glassed steel dryer-blender

On test at one of the nation's leading pharmaceutical companies recently, the new Pfaudler glassed steel blender (patents applied for) came through with flying colors on several organic products.

The most difficult test, which was done first, involved a material



One of the biggest so far — 255 cu. ft. When fully charged, this giant blender weighs approximately 20,000 lbs. The heavy-duty gear drive tumbles bucket at 8 RPM with a 15 HP motor. Unit is provided with a magnetic brake, giving you instant and positive control.

with the consistency of whipped cream. Results were amazing and *proved that one Pfaudler dryer-blender could be used to dry seven to ten different products, replacing three conventional tray dryers of 100 trays each!*

The manufacturer immediately placed an order for a six-foot dryer-blender on the spot. Results like these speak for themselves.

You get more than just a dryer with any Pfaudler unit—you get a dryer-blender which gives you these important advantages: high heat transfer, lower power requirements, corrosion resistance, uniform drying and blending. You are invited to test your products in our laboratory test blender at any time, sending your own men along to observe results, if desired. Or, if preferred, Pfaudler will arrange to send a field unit to your plant. Just contact your nearest Pfaudler office or write direct.

Purer distillates from new Pfaudler wiped-film evaporator

Pilot plant test unit now available

A substantial number of two-inch Pfaudler laboratory-type wiped-film evaporators are already in use on products ranging from volatile solvents to heavy oils and fats. Results to date indicate high efficiency in obtaining pure distillates. Product quality has been particularly improved on such counts as clarity, odor and color.

Send for questionnaire

To help you further evaluate the advantages of high-vacuum distillation for your products on a pilot plant scale, Pfaudler has equipped its testing laboratory at Rochester

Ready to test your products—Now you can check all the advantages of vacuum distillation before investing in equipment. Product purity, faster production and increased profit are among the advantages you may gain.

with the 12" unit shown above. Please write for a copy of our data questionnaires – forms number 23 and 24. It is, of course, essential for us to know what the physical and chemical properties are in order to determine the feasibility of testing your material.

You can obtain the questionnaire by using the coupon below. Information on the equipment itself is contained in Data Sheet 39, also available on request.

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What's Happening . . .

. . . in the Industry

Refiner Cutbacks Speed Oil to Europe

Voluntary cuts come sharp and fast as industry attempts to alleviate shortages in Western Europe.

Even as President Eisenhower posed a threat of government controls over the domestic oil industry last month, American refiners continued their dramatic cutback of crude runs. Their goal was to make available as much crude oil as possible for shipment to Western Europe to alleviate the shortages created by the closure of the Suez Canal.

Shell Oil Co. deviated from the usual procedure of reducing refinery runs when it announced that it had advanced Gulf Coast refinery overhaul schedules. This released for shipment an extra million barrels of crude that normally would not have been available for months.

Shell president H. S. M. Burns stated that one catalytic cracking unit will shut down "very soon", and another unit not scheduled for overhaul until May will also be taken off stream.

Burns added that at the end of February, Shell had made available for shipment to Europe over four million barrels of crude oil and 1.5 million barrels of fuel oil and other products.

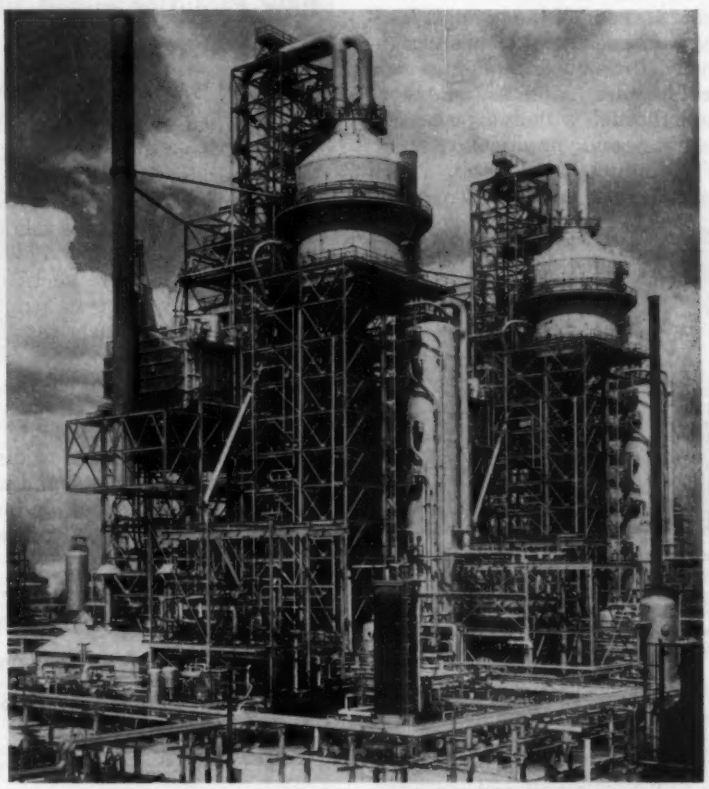
The Texas Co. made an extra 20,000 bpd available for shipment to Europe by cutting runs at its Port Arthur, Texas refinery. Even before this latest cut, Texaco was shipping five times as much crude and products to Europe as it did prior to the emergency.

Texaco said it has averaged sending 104,000 bpd to Europe as compared with 20,000 bpd before the Suez situation developed. This has been done the company said, by increasing shipments to Britain from Trinidad, purchasing and taking from stocks from the Caribbean and Gulf Coast sources, and diverting Arabian crude from Sidon normally destined for Western Hemisphere.

Gulf Oil Corp. cuts came fast and sharp as company officials announced reductions of 10,000 bpd at Port Arthur, 10,000 bpd at Philadelphia, and 9000 bpd at Toledo. These 29,000 bpd were diverted for shipment to Europe.

A short time later Gulf announced an additional cut of 30,000 bpd at its Port Arthur refinery. This was accomplished by temporarily closing down one of the big stills for an overhaul.

Gulf, which does not normally ex-



Sets New World Record

A world record of 48 million barrels of feed stock processed in a continuous run is claimed by Esso Standard Oil Co.'s Baton Rouge refinery for its fluid catalytic cracking unit. The unit has run continuously for 881 days since its last shut-down to set a new days-operated record among catalytic cracking units in refineries of companies affiliated with Standard Oil Co. (New Jersey). The unit was shut-down recently for a general inspection. Even after this long run, inspection showed it could have been safely operated for an additional period of time.

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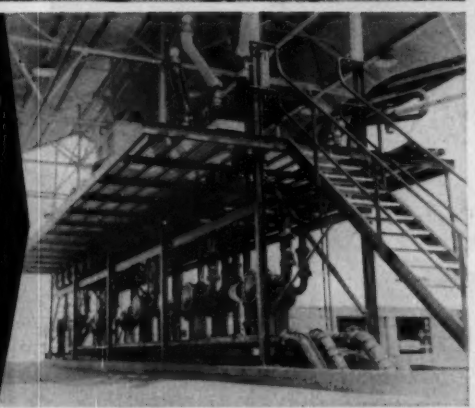

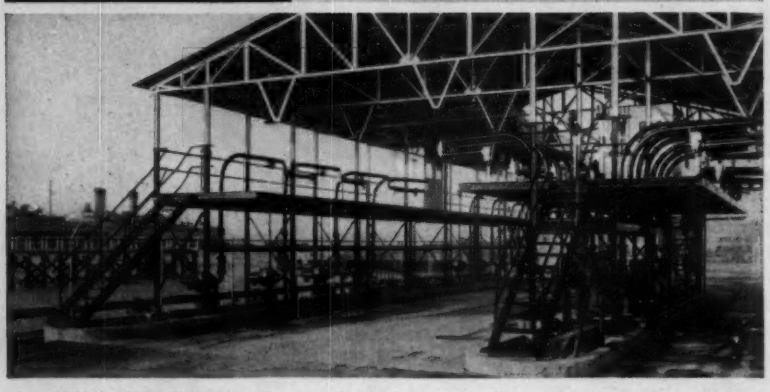

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Important Safety Features

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What's Happening. . .

port any crude, said that at the end of February, it was responsible, directly or indirectly, for diverting a total of 6,807,000 barrels of crude oil to foreign countries since last October. In addition, 1,144,000 barrels of products have been or will be moved to Europe by the end of March. Gulf has also diverted to Europe 60,000 bpd of Middle East crude normally scheduled for this country.

Cities Service Co. cut refinery runs of crude oil in its Eastren Coast and Gulf of Mexico refineries by 10,000 bpd, with the savings being released for shipment to Western Europe.

Earlier, the company reduced by approximately 70 percent, imports from all foreign sources. Company officials estimate the Cities Service has made available or has transported 64,111 bpd since December 1.

Diversion of additional cargo is still being arranged.

Tidewater Oil Co. announced that it reduced scheduled refinery runs on the East and Gulf Coasts by 900,000 barrels. Refinery yields were changed to increase distillate and fuel oil output, while product stocks were reduced to minimum levels.

Other steps taken by Tidewater include reducing by 1.44 million barrels scheduled imports of Middle East crude; diverting company tankers carrying 970,000 barrels; and making tanker space available by substituting 400,000 barrels of Canadian crude.

Continental Oil Co. reduced refinery runs in the Rocky Mountain and Mid-Continent areas by five percent. The company also plans to purchase excess distillate stocks in the Mid-Continent area in an effort to move them to the Gulf Coast for shipment to Europe.

The Standard Oil Co. (Ohio) says that its refinery runs this quarter will be 500,000 barrels, or about 5600 bpd below the company's previously scheduled level. This crude is being made available for export at Gulf Coast ports.

Pure Oil Co. after having an 11 percent decline in runs for the fourth quarter of 1956, announced that for the first quarter of 1957 runs have been reduced four percent. Still fur-

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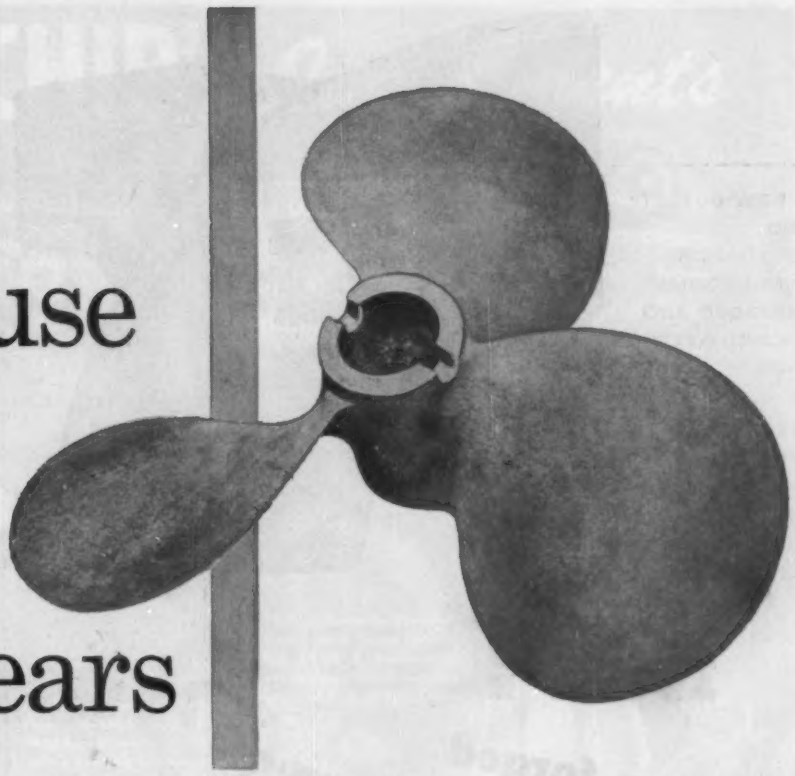
Still in use after 4 years



in hot sulphuric acid and chlorides

PROBLEM.... Agitator propellors were failing at a rate of one every three months in dye kettles where hot sulphuric acid was mixed with chlorine-bearing organic chemicals. Sometimes corrosion was so severe that the propellors fell off the shaft and chipped the kettle lining. This required a major overhaul.

REMEDY..... Agitator shaft and propellor made of HASTELLOY alloy D were installed.

RESULT..... Four years later the same propellor and shaft made of HASTELLOY alloy D are still in service.

HASTELLOY alloy D has excellent resistance to sulphuric acid in all concentrations and at temperatures up to the boiling point. In addition, it is resistant to many other acids and salts frequently used in solution with sulphuric acid. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company office.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

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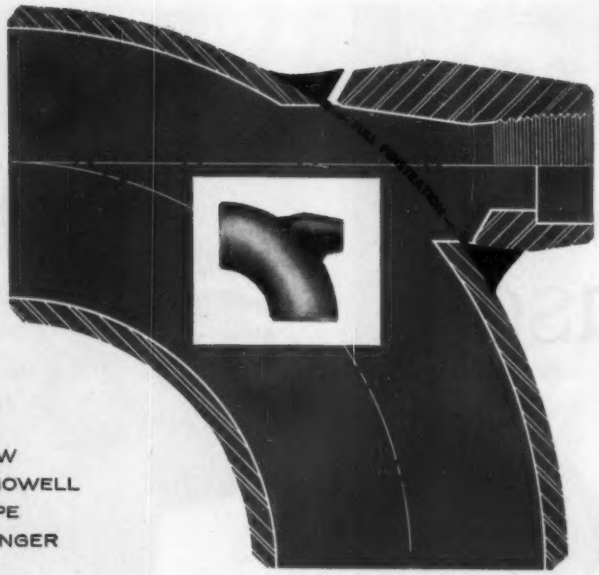

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with full penetration weld

Full penetration weld drop forged fittings available from stock in the following materials:

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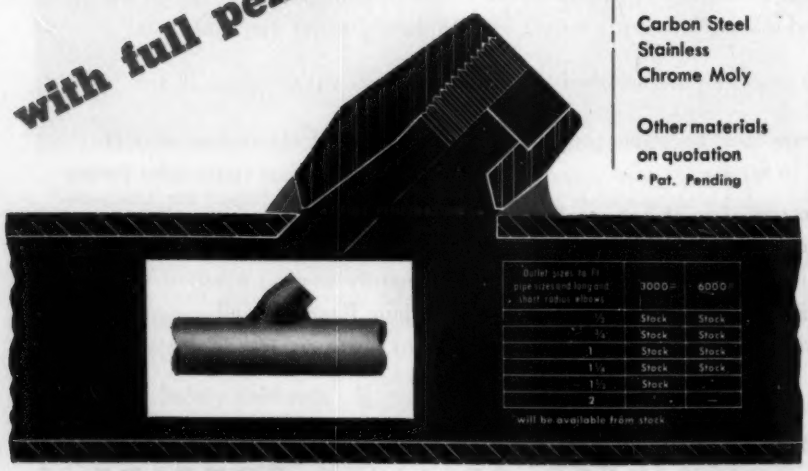
Other materials on quotation

* Pat. Pending



Outlet sizes to fit pipe sizes and long and short radius elbows	3000#	6000#
½	Stock	Stock
¾	Stock	Stock
1	Stock	Stock
1¼	Stock	Stock
1½	Stock	—
2	—	—

will be available from stock

BONNEY

Pennsylvania Division

BONNEY FORGE & TOOL WORKS

ALLENTOWN, PA. DEPT. M

What's Happening . . .

ther reductions are being contemplated.

Sinclair Refining Co. cutback 15,000 bpd below the January level at its seaboard refineries. The company said the cutback "will continue at least through the end of March." The plants affected include those at Marcus Hook, Pa., Houston, and Corpus Christi, Texas.

D-X Sunray Oil Co. has cut runs at its two Oklahoma refineries by 7000 bpd. This is equivalent to approximately seven percent of the companies normal 100,000 bpd throughput.

Kerr-McGee Oil Industries, Inc., shut down the crude stills at its Wynnewood refinery thereby releasing some 450,000 barrels. Direct sales of another 315,000 barrels from crude stocks at its Cushing, Okla., refinery were made in an effort to replace domestic crude being shipped to Europe.

Husky Oil Co. cut refinery runs by approximately five percent and changed processing to reduce gasoline output by 16 percent.

Phillips Petroleum Co. made one million barrels of crude available by reducing refinery runs. Company officials said that immediately after the blocking of the Suez Canal, Phillips made arrangements to supply hard-pressed Europe with more than four million barrels of crude.

Socony Mobil Oil Co. president A. L. Nickerson summed up the accomplishments of the industry as a whole by saying, "They add up to what is probably the largest and most rapid shift in distribution of any commodity ever achieved in peacetime."

Europe Getting Near 90% Of Needs Says API Chief

President of the API, Frank Porter, predicted recently that "within a short time it will be shown that Western Europe is receiving not approximately 80 percent of normal product needs, but something closer to 90 percent."

The forecast was made at a news conference in Washington, at which he also struck back at those who are "publicly impugning our motives and our methods, and are misrepresenting our achievements."

Porter made it plain he felt that "some people" apparently were using "alleged deficiencies in the oil-for-Europe program as a stick to beat the petroleum industry."

The API President, declared that Western Europe has been saved from its most serious fuel crisis in history by emergency action of unparalleled magnitude. He said individual oil companies accomplished the "largest and fastest shift in the distribution of any commodity ever achieved in peacetime, first through their own initiative and later through the operation of the Midle East Emergency Committee, at the request of, and under the supervision of, the Federal Government."

Porter expressed grave concern over the "unwarranted and unsupportable attacks" on the petroleum industry in recent weeks. He said that recent hearings in Washington have not only confirmed the success of the oil-for-Europe program, but that each new report from domestic and overseas sources emphasizes it more.

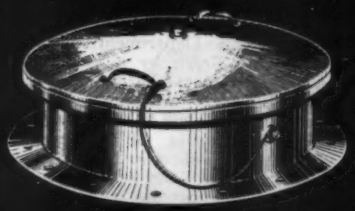
It is on the basis of such new informa-

For more data on advertised products, use Readers' Service Cards, last page.

"BLUE CHIP" *Investments*

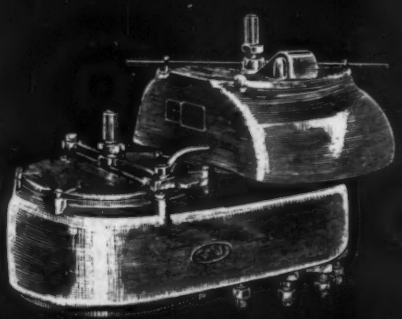
S&J Pilot Operated Safety Relief Valve, Fig. ST-5000, provides positive protection to tanks from overpressure within range from 1 to 10 pounds.

The Shand & Jurs line of Pressure and Relief Valves and equipment for petroleum tanks truly provide extra "dividends" from the air. These conservation fittings deliver substantial savings by reducing evaporation losses, consequent reduction in volume of liquid as well as loss of gravity. There is an S&J Breather Valve or Vent available for almost every tank requirement.

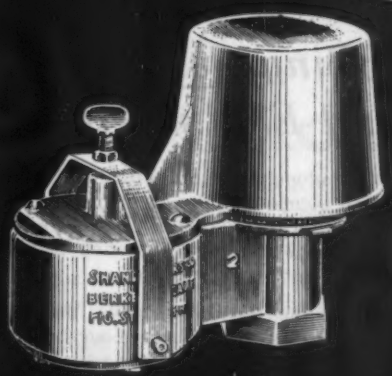


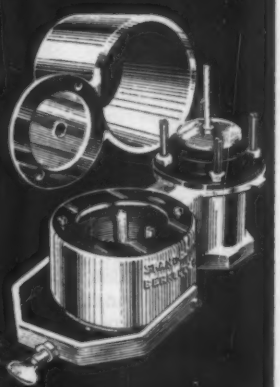
S & J Emergency Vent, Figs. ST-5455 and ST-5455A, provide emergency venting for surges, unusual thermal conditions or over-filling. Fits Standard 20" A.P.I. manholes.

S&J Combination Breather Valve and Gage Hatch, Fig. ST-1615. Economical venting for small marketing and bulk plant tanks.



S&J TITE-SEAL Vapor Saving Breather Valve, Fig. ST-7575, designed for vapor conservation systems provides tightest seal against pressures and vacuums below valve settings.





S&J Breather Valve, Fig. ST-3695R features a one piece vacuum-pressure valve cover for quick accessibility. Available in 2, 3 and 4 inch sizes.

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MEXICO, D.F.: Dalmo Comercial, S. A.
CARACAS: Sinclair Spence, C.A., Edificio Galipan
ENGLAND: Whessoe, Ltd., Sales: 25 Victoria St., London S. W. 1
Whessoe, Ltd., Works: Darlington, County Durham

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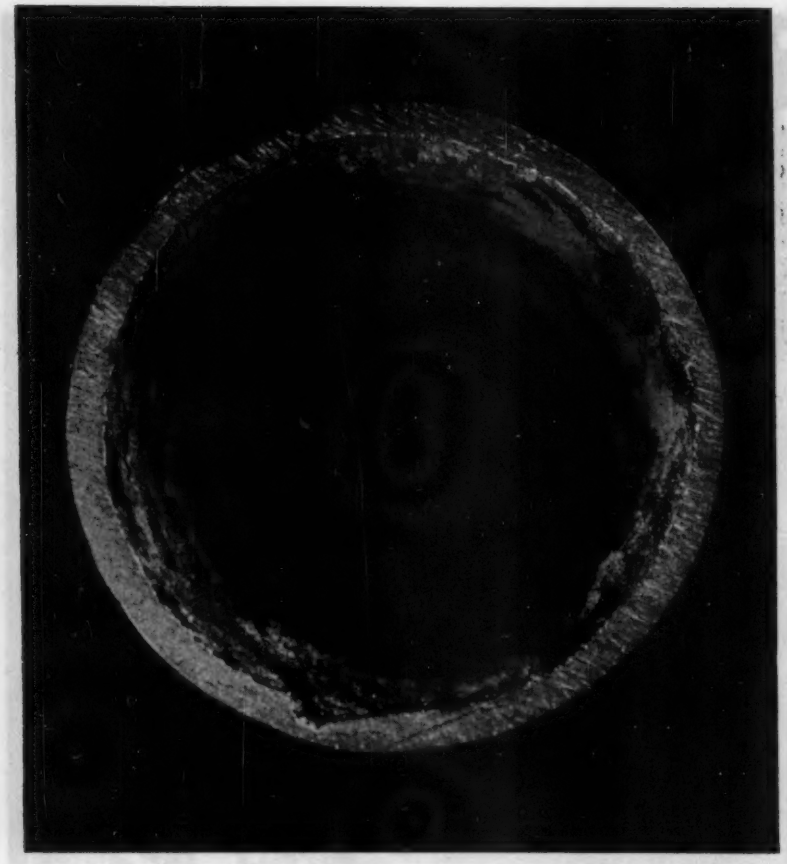

Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

Controlling Corrosion in Fluid Engineering

Corrosion seldom works alone. Together with heat, pressure and abrasion factors, it compounds the problems of fluid engineering. But when you have valve design problems involving corrosion, you can look to the engineering leadership available at S. Morgan Smith for assistance.

You can use R-S Rubber-lined Butterfly Valves, for instance, to handle many special applications. The rubber lining protects the entire valve body, gives you corrosion resistance with maximum economy. Where your processing problem demands additional engineering, you can draw on the broad SMS background of experience in specialized valve applications.

There is a complete SMS line – Rotovalves, R-S Butterfly Valves and Ball Valves – to meet your fluid control problems. To obtain full information, contact our nearest representative, or write S. Morgan Smith Company, York, Penna.

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AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

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What's Happening . . .

tion, he continued, that he is able to predict that figures to be released soon will reveal that consumers in Western Europe are receiving close to 90 percent of their normal requirements.

He declared:

"This is a record of achievement which should be enlightening even to those Congressional committee members who pretend to see something sinister in the fact that patriotic Americans are participating in this voluntary effort, at the request of their government, and at some hazard to themselves and their companies."

Grand Jury to Probe Oil

A federal grand jury investigation of the production, refining, and distribution practices of the oil industry has been ordered by Judge Albert V. Bryan of the Federal District Court in Alexandria, Va. The Justice Department has been considering the grand jury approach to some questions being raised as to the possibility of "collusion" in price increases for crude oil and its products.

The Justice Department motion was presented to Bryan by a team of seven antitrust attorneys headed by Horace Flurry. Judge Bryan called for a special grand jury which was to have met March 4.

The Department of Justice motion called for "investigation of alleged violations of antitrust laws by companies, corporations, and persons engaged in the distribution, production, storage, purchase, and sale of petroleum and petroleum products.

ODM Approves Tax Grants

The following approvals for rapid tax amortization have been approved by the Office of Defense Mobilization:

Wilshire Oil Co., Inc.—10,000-bpd Platformer and Unifiner (catalytic reforming and hydrodesulfurization) at its Norwalk, Calif., refinery (application had previously been denied on dispersal grounds), 65 percent on $2,735,000.

Frank M. Starling, Houston—two 80,000-barrel storage tanks for lease to U. S. Air Force, Doraville, Ga., 65 percent on $429,000.

Fewer Grades of Asphalt

In another move to streamline road paving methods, The Asphalt Institute has adopted a reduction in the number of grades of paving asphalts from nine to five.

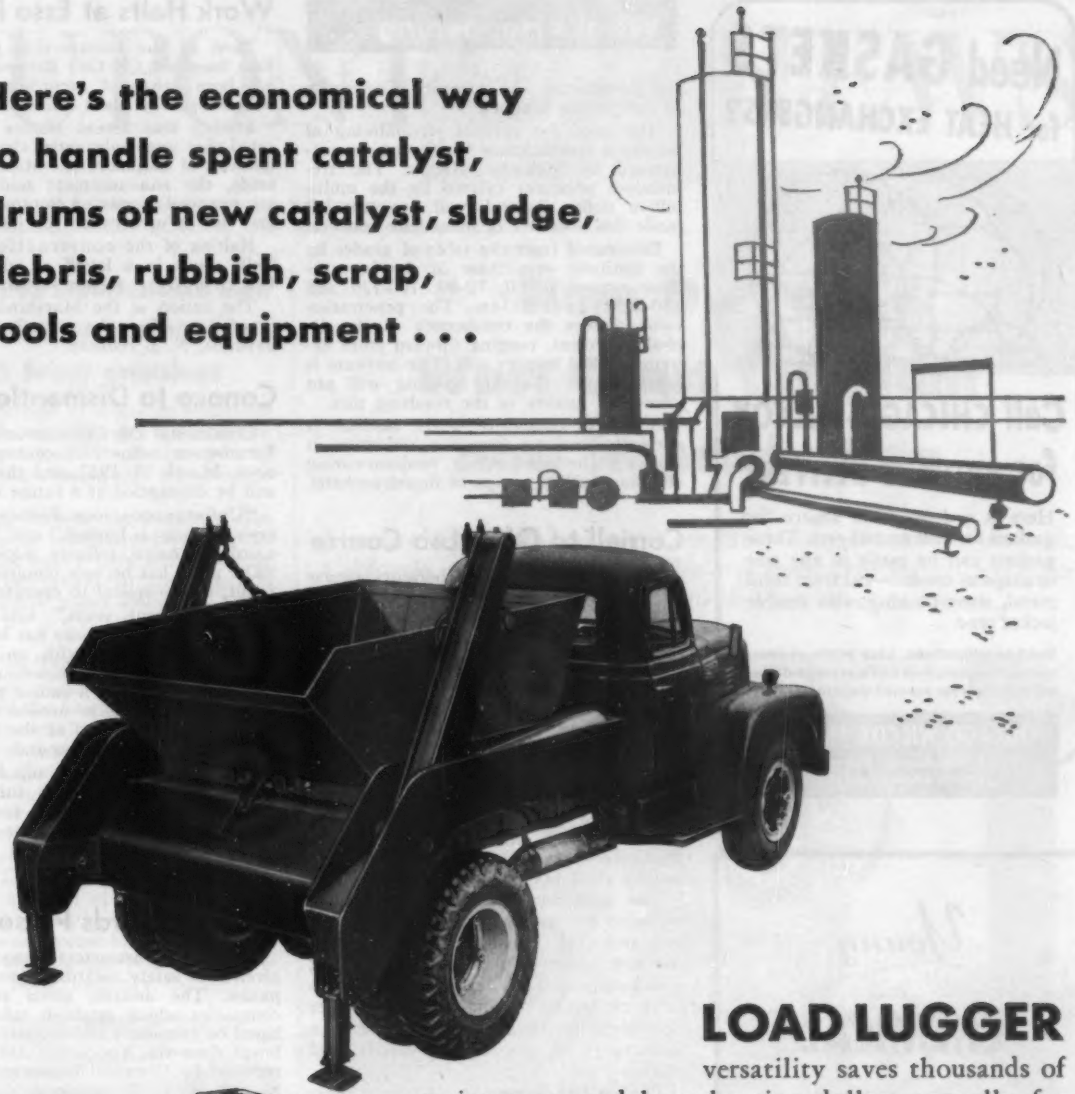
In making the announcement President J. E. Buchanan said the institute's action followed a series of exploratory discussions with asphalt users, highway officials and refinery representatives.

Four basic paving grades now officially recognized by the Institute are listed as 60-70, 85-100, 120-150 and 200-300 penetration. A fifth grade of 40-50 penetration asphalt is recommended for special and industrial uses.

"The advantages of the reduction in grades are evident," said Buchanan. "It will simplify the storage and handling problem at the refinery and will certainly make these standard grades more readily available from all asphalt refiners. In turn, the user can reasonably expect better serv-

For more data on advertised products, use Readers' Service Cards, last page.

Here's the economical way to handle spent catalyst, drums of new catalyst, sludge, debris, rubbish, scrap, tools and equipment . . .



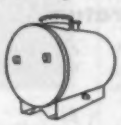
LOAD LUGGER

versatility saves thousands of maintenance and housekeeping dollars annually for refineries throughout the country. Disposing of combustible material, handling scrap, tools and equipment in turnaround operations, simplifying scrap disposal in maintenance shops, keeping refinery premises free of debris are a few of the ways Load Lugger reduces refinery maintenance costs.

Let us show you performance facts and figures and full details about The Load Lugger System—Load Lugger equipped truck + detachable Load Lugger containers. Write today.

LOAD LUGGER CONTAINERS

are available for handling solvents, liquids, gases. Practically any type of material can be moved efficiently with the Load Lugger system.



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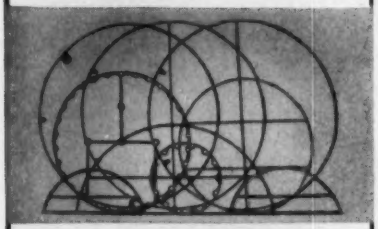
Need GASKETS for HEAT EXCHANGERS?



Call CHICAGO-WILCOX for PROMPT DELIVERY

Here is a dependable source for gaskets for heat exchangers. These gaskets can be made in any size or shape as needed—cut from solid metal, sheet-packing; also double jacket type.

Send specifications, blue prints or templates, for quotation and a prompt-delivery schedule for normal stocking orders.

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CHEMICAL ENGINEER

Midwest Engineering Firm Wishes Young Chemical Engineer to Specialize in Design of Fractionating Equipment. Rapid Advancement If You Have What it Takes.

Address:
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What's Happening . . .

ice in delivery and superior distribution of the paving product."

The need for general streamlining of materials specifications has long been recognized by highway officials. The tremendous pressures exerted by the multi-billion dollar Federal road program has made this a matter of immediate concern.

Eliminated from the table of grades by the institute were those in the intermediate ranges: 50-60, 70-80, 100-120 and 150-200 penetration. The penetration value defines the consistency of the asphaltic cement, ranging upward from extremely hard to very soft. The institute is satisfied that the skip-grading will not affect the quality of the resulting mix.

A project committee of the institute is currently working toward a reduction in grades of the rapid-curing, medium-curing and slow-curing groups of liquid asphalts.

Cornell to Offer Lab Course

The Cornell summer laboratory course in Techniques and Applications of the Electron Microscope will be given again this summer from June 17 to June 29, by the laboratory of electron microscopy in the department of Engineering Physics. This summer the course will be given primarily for workers in the fields of physics, chemistry and metallurgy.

Phillips Process to Japan

Phillips Petroleum Co. has licensed Showa Denko K. K., of Japan, to use the Phillips-developed catalytic process for making rigid polyethylenes.

The agreement grants Showa Denko exclusive use in Japan of Phillips patents and technical knowledge for producing this new family of plastics. Showa Denko, with headquarters in Tokyo, is a manufacturer of fertilizers, aluminum and other electrolytic metals and electrochemicals, a wide range of inorganic chemicals, and plastics.

Phillips has licensed its polyolefin process to four U. S. chemical companies and six overseas firms in as many countries.

Work Halts at Esso Plant

Most of the construction program at Esso Standard Oil Co's Baltimore refinery has been stopped according to an announcement by plant officials.

Stating that recent studies have indicated that some substantial change or curtailment of Baltimore operations should be made, the announcement said, "continuing to spend money on improvements that may not be used cannot be justified."

Halting of the construction program "will result in a layoff of approximately 175 employees," it was stated.

The action at the Maryland plant will in no way affect the operations at Esso's Bayonne, N. J. refinery.

Conoco to Dismantle Plant

Continental Oil Co. announced that its Farmington refinery discontinued operations, March 10, 1957, and that the plant will be dismantled at a future date.

"Unfortunately, our Farmington refinery's capacity is limited," said H. H. Kinnaird, Conoco refinery superintendent. "The plant has become obsolete and, as a result, uneconomical to operate.

"Until recent years," said Kinnaird, "the Farmington refinery has been able to produce a gasoline with an acceptable octane rating. Today, however, with the equipment available, it cannot produce the higher octane gasoline needed for modern engines, and operation of the facility has become economically unsound.

"We will continue to supply our customers in this area from other sources and with an expanded and complete line of high-quality petroleum products," he added. "We regret we find this move necessary."

Safety Awards Presented

National Constructors Association has given four safety awards to member companies. The awards, given annually to companies which establish safety records based on frequency and severity of injuries lower than the Association average, were received by Chemical Construction Corp., New York; C. F. Braun & Co., Alhambra, Calif.; Sanderson & Porter, New York; and Koppers Co., Inc., Pittsburgh.

Erratum

Equation (2) in "How to Design Perforated Trays" by Messrs. Leibson, Kelley, and Bullington on page 128 in the February issue of Petroleum Refiner should have read as follows:

$$L_D = \left[P_{dc} + L_{e_{avg}} + \left(h_v\right)\frac{\rho_V}{\rho_L} + P_D + L_{e_{avg}}\right]\frac{\rho_L}{\rho_L - \rho_V} - \left[H + L_{e_{avg}}\right]\frac{\rho_V}{\rho_L - \rho_V} \qquad (2)$$

Conclude Shale Oil Best for Jet and Diesel Fuel

From all indications Union Oil Co. of California and the U. S. Navy have concluded that shale oil's greatest potential lies in the direction of jet and diesel fuels, not gasoline. This is from a competitive (with product from crude) cost standpoint. Fred L. Hartley, research vice president of Union said that shale from retort, after coking and hydrogenation, could be sold directly as a superior crude oil priced in keeping with its freedom from sulfur and its lack of fuel oil.

"Or alternately," he added, "by a simple thermal distillation of the hydrogenated coker distillate, we can split the

For more data on advertised products, use Readers' Service Cards, last page.

DU PONT *Petroleum Chemicals* NEWS

One of a Series of Bulletins for the Petroleum Industry

MARCH 1957

Locomotive maintenance men report longer bearing life with fewer greasings

After switching to a grease based on Du Pont Estersil GT (grease thickener), one company substantially reduced bearing maintenance and replacement costs.

Running almost continuously, the company's 22 locomotives many times a day haul heavy cars from mine to surface. They operate in tandem to pull 210-ton loads seven miles up a 3% grade.

Bearing maintenance reduced

Under such rugged service, the temperature of the four armature bearings in each locomotive rises as high as 300°F. Before an estersil-based grease was used, the bearings were greased every month. Now with estersil grease, the job is done only every *two* months.

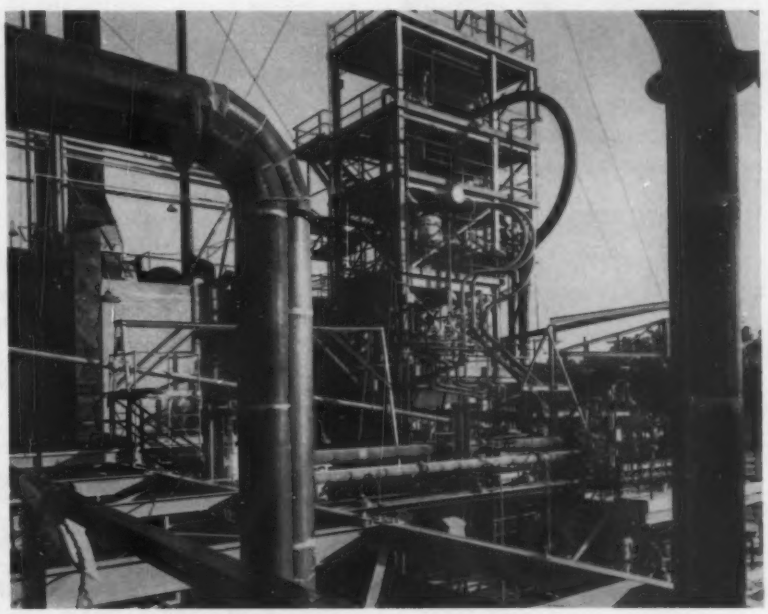
The company's mechanics report important savings on bearing replacement as well. They point to the company's previous average of one bearing replacement every two weeks. Since estersil-based grease has been used (six months), not a single bearing replacement has been necessary.

This compact locomotive operates under the toughest conditions. The grease packed into its armature bearings must have special properties to withstand the dust, high shear, and hot bearing temperatures.

The unique qualities of Du Pont Estersil GT are behind such dependable service. Estersil greases show outstanding resistance to mechanical breakdown and are practically immune to water, extreme heat and extreme cold.

New Du Pont West Coast TEL plant now in production

The new tetraethyl lead plant constructed by Du Pont at Antioch, California, is now on stream. This will make possible extra-fast deliveries of California-made TEL to all West Coast refiners.



Top of TEL pipe alley looking toward reactor tower.

The new plant is located approximately two miles east of Antioch on the San Joaquin River.

Integrated facilities

The new plant was built to meet the needs of the fast-growing West Coast oil industry. The present Du Pont Petroleum Chemicals Division regional laboratory at El Monte, and sales offices in Los Angeles, San Francisco and Seattle, together with the new plant, will provide complete service for TEL-users on the West Coast.

Plant most modern in the world

The new Du Pont plant has the most modern TEL manufacturing facilities in the world, incorporating in its design and equipment the latest continuous processing advances and many other production refinements.

A Du Pont Petroleum Chemicals Division representative will be glad to give you more detailed information about estersil GT and to provide samples. Contact any of our sales offices.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DU PONT *Petroleum Chemicals* NEWS

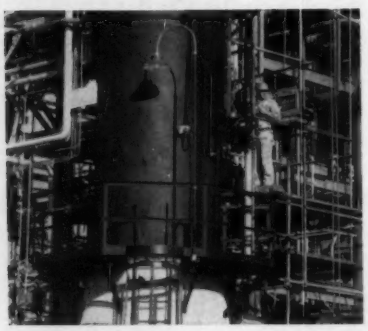
CONTINUED

New TEL Plant

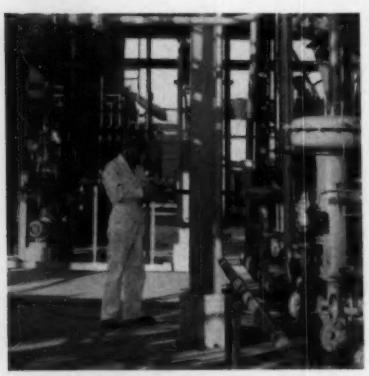
Another new Du Pont plant for making "Freon"* refrigerants and propellants is also located at Antioch. The "Freon" facilities were completed and production was started last fall.

Du Pont becomes a larger West Coast customer

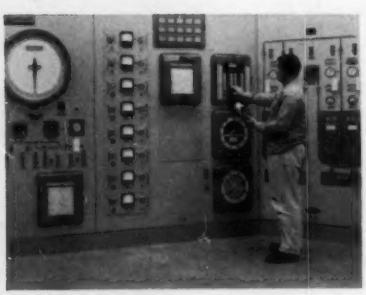
The two Du Pont plants at Antioch have become important new customers for large volumes of materials produced locally. Du Pont employees at Antioch already number 325; they were recruited locally.



Base of ethyl chloride column, TEL area.



Operator logging data in TEL area.



TEL central control room.

THESE MEN HEAD NEW ANTIOCH TEL PLANT

HENRY L. GREENE

DONALD C. MILLER

Top management posts at our new Antioch plant have been filled by Henry L. Greene and Donald C. Miller. Mr. Greene is plant manager and Mr. Miller assistant plant manager of the combined new TEL and "Freon"* refrigerant and propellant plants.

Mr. Greene joined the Du Pont Company in 1934 as a senior engineer. He advanced to supervisory posts at the Chambers Works, in New Jersey, then moved to Du Pont's neoprene plant at Louisville, where in 1946 he became assistant manager. In 1952 he was appointed assistant manager of the Savannah River Plant. He is a chemical engineer, a graduate of Kansas State College.

Mr. Miller came with Du Pont in 1937 as an analyst at Jackson Laboratory, Chambers Works. Following assignments in several other plants, he returned to the Chambers Works in 1943, where he became senior supervisor in TEL production. When in 1951 he was awarded the position of assistant works engineer, he was one of the youngest men ever to fill the job.

Mr. Miller received his B.S. in chemical engineering from Ohio State University.

**Registered Du Pont trademark.*

LITERATURE AVAILABLE

Here is a partial listing of the many bulletins, reports, booklets, technical papers, and other aids available to you through any of the Du Pont Petroleum Chemicals Division offices:

Du Pont Estersil GT—A brief description of the properties, composition and applications of estersil grease thickener. Explains estersil grease preparation and contains handling information.

New Du Pont Dry-dye Eduction Probe and No-dust Drumhead—A folder describing and illustrating the revolutionary new dry-dye eduction devices, which make gasoline dyeing a cleaner, faster, and more efficient operation.

Sales Promotional Aids for Dealer Meetings—Describes the many Du Pont aids available for dealer meetings. A handy check list for anyone planning dealer meeting programs.

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Cleveland 15—25 Prospect Ave. . . . SUperior 1-1363
Houston 2—
705 Bank of Commerce Bldg. . . . . CApitol 5-1151
Los Angeles 17—612 So. Flower St. . MAdison 5-1691
New York 20—
1270 Ave. of the Americas . . . . . COlumbus 5-2342
Philadelphia 2—3 Penn Center Plaza . . LOcust 8-3531
Pittsburgh 22—1 Gateway Center . . . ATlantic 1-2933
San Francisco 4—111 Sutter St. . . . . EXbrook 2-6230
Seattle 3—4003 Aurora Ave. . . . . MElrose 6977
Tulsa 1—1811 So. Baltimore Ave. . . . . LUther 5-5578
In Canada—Du Pont Company of Canada (1956) Limited, Petroleum Chemicals, 85 Eglinton Ave. East, **Toronto 12**—Ontario . . . . . HUdson 1-6461
In Other Countries—Petroleum Chemicals Division, Export Sales, 7496 Nemours Bldg., Wilmington 98, Del., OLympia 4-5121, Ext. 2962

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. . . through Chemistry

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

A-3638

Printed in U. S. A.

product into top-grade products much in demand by the military—jet and diesel fuel." Hartley also disclosed that his company expects to complete all phases of its oil shale research by no later than the end of 1957.

Captain A. S. Miller, director of the Office of Naval Petroleum Reserves said, "We have adopted a new approach. So far as we are concerned, shale oil as a source of jet fuel, diesel, and light oil fuels is more important and gasoline may be considered a by-product." He also added that his agency has many facts to present to the House Armed Services Committee to back up the plea for reopening the government's shale oil plant at Rifle, Colo., for research by the Navy on jet fuel possibilities of shale oil.

The Rifle plant was put on a stand-by basis under the Navy last fall when Congress refused funds for continuation of the Bureau of Mines research that had been aimed at converting shale oil to gasoline at a cost competitive with that of converting crude to gasoline.

Union's demonstration plant near Grand Valley, Colo. is nearly complete and operating shakedown tests are expected to begin shortly. By the end of the year Hartley said Union's research program will have covered:

1. Designing, constructing, and operating a commercial prototype of the Union Oil retort.

2. Establishing experimentally the optimum conditions for refining shale oil.

3. Planning and integrating the processing steps leading to the most profitable output of marketable products from shale oil.

4. Establishing costs for a commercial mining operation.

Conoco to Sponsor Contest

A contest in colloid and surface chemistry among college undergraduates has been announced by the University of Southern California. It will be sponsored by Continental Oil Co.

Students of chemistry and chemical engineering in all accredited colleges and universities in the United States and Canada are eligible if they are full-time undergraduates on April 1.

A 5000-word report on original research in fields of colloid or surface chemistry, or an essay on "The Contribution of Albert Einstein to Colloid Chemistry" may be submitted for a $500 first prize, $200 second prize, $100 third prize, excellence prize of $500 or honorable mention prizes of $50. The excellence prize may also be awarded to the best entry if it satisfies exceptionally high standards worthy of $1000.

Entry blanks may be obtained immediately from Prof. K. J. Mysels at the University of Southern California.

Form New Departments

Ethyl Corp. has formed a separate Engineering department which will encompass the general engineering and construction coordination functions. These were formerly a part of the Research and Engineering department.

The new department was organized be-

Not the bottle, but the contents. For this vial contains the greatest obstacle in the reclamation of slop oils—the highly stable oil/water interfacial emulsion that remains after the usual settling, skimming, sedimentation, and chemical treatment.

Dicalite filtration breaks this emulsion...and slop oil filtration units now operating with Dicalite prove that it's not only economical, but profitable! Reports from several refineries indicate that the value of the separated, clean oil recovered by Dicalite filtration will amortize the entire cost of the filtration unit in less than two years, after which oil recovery will return a clear operating profit.

Dicalite diatomite filteraids break this tight emulsion by rupturing the minute oil globules as they pass through the filter cake, and by trapping the minute solids which help to make this emulsion so stable. After filtration, clean oil and water separate easily into distinct layers on standing. The water contains so little oil that it may be re-cycled for process water in some applications, or may be discharged to waste without violating the stream pollution laws of any state.

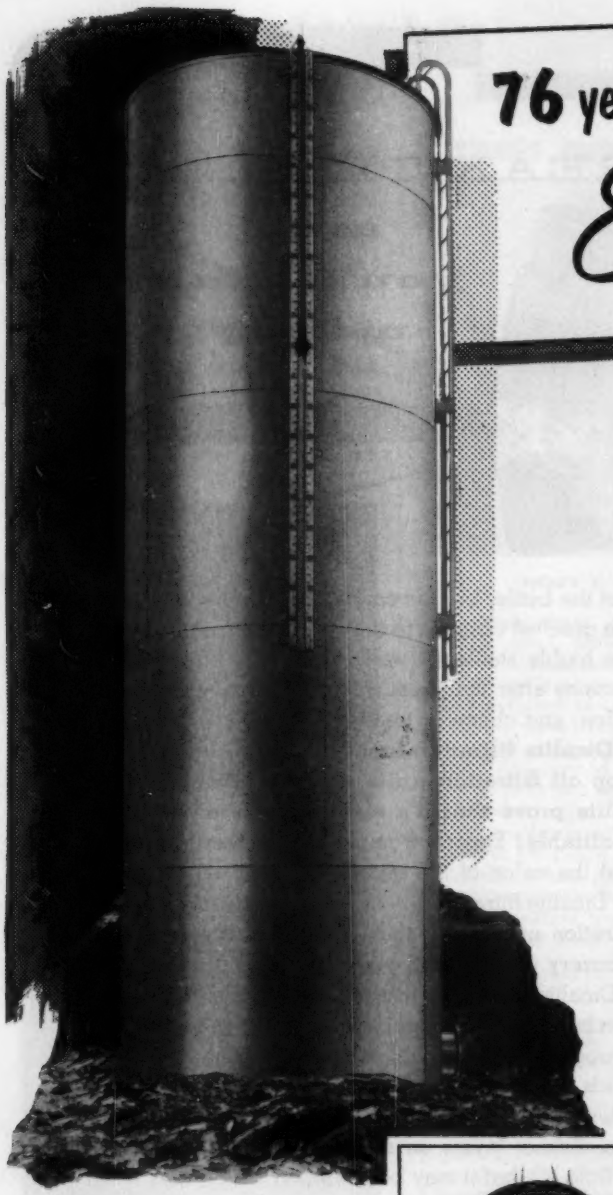
Write today for more complete information.

Dependable GLC GREAT LAKES Dicalite DIATOMACEOUS MATERIALS

DICALITE DIVISION | Great Lakes Carbon Corporation, 612 S. Flower St., Los Angeles, Calif.

For more data on advertised products, use Readers' Service Cards, last page.

76 years of KOVEN fabricating *Experience* built into every job



Acid Storage Tank Made of Stainless Clad Steel

See Sweet's Catalog File and Chemical Engineering File

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KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.

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NICKEL • INCONEL • ALL CLAD MATERIALS
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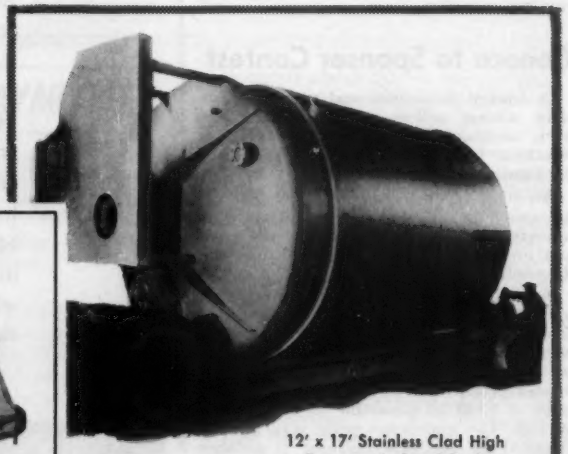
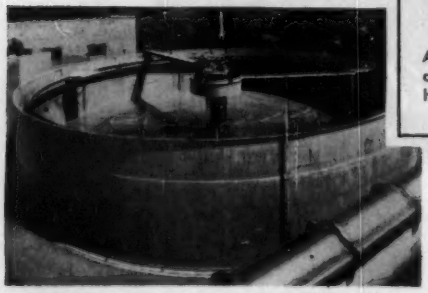
Fabrication to all A.S.M.E. Codes

A.S.M.E. Steel Reducer 13' large diameter; 6' small diameter; 18' high, 7/8" steel throughout



12' x 17' Stainless Clad High Pressure, Jacketed Tank



80' Diameter Clarifying Tank—Field Erected

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What's Happening. . .

cause of the enlarged scope of the company's research and development effort as well as the construction planning made necessary by the continuing expansion program. The new departmental organization will permit integration of plant general engineering and construction functions and at the same time free Ethyl's research staff to concentrate exclusively on research and development programs.

The name of the Research and Engineering department has been changed to the Research and Development department.

Also, Shell Development Co.'s Emeryville, Calif., research center has formed a new department to develop and apply mathematical and high speed computing methods, and thus make it possible for new and improved processes to be put into operation in a shorter time.

Advanced mathematical techniques for example, are being used to obtain improved design and control of refinery and chemical plant distillation columns. Mathematical and computer calculations are being developed to predict both the steady and time varying operation of a column before it is built.

Navy to Present Shale Plan

The House Armed Services Committee will soon hold hearings on the Navy's plan for a new research project at Rifle, Colo., oil shale plant. The Navy plan calls for a $2 million annually during the next five years for research by a private contractor. In a surprise move, the budget request by the administration for fiscal 1958 called for the transfer to the Bureau of Mines of present maintenance funds for the Rifle plant which is presently on a standby status.

Substitute Alloy for Steel

Proper application of alloy and clad steels in many cases can bring a measure of relief in the present acute shortage of heavy steel plate, declared President Charles Lukens Huston Jr. of the Lukens Steel Co.

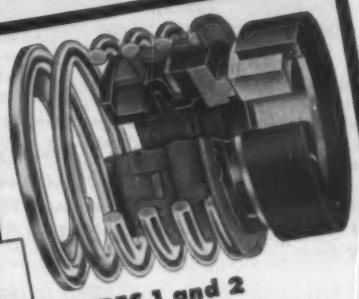
As for the long-term outlook for heavy plate, however, Huston told the Steel Plate Fabricators Association at their 24th annual meeting that supply "is expected to remain generally tight for at least the next five years" and that "satisfactory financing is the key to the period of time necessary for expansion of production to meet this demand."

Explaining the relief that wider use of alloys could bring, Huston cited recent case histories in which metal savings of between 18 and 33⅓ percent have resulted from the use of lighter gages of certain alloys whose higher strength enabled them to perform as well as heavier gages of ordinary carbon steel. In many instances, use of more expansive alloys resulted in over-all cost savings because their lighter weight cut fabrication and shipping costs.

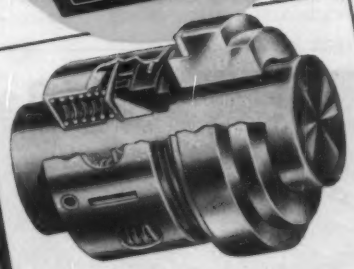
This possible short-term relief to stretch available heavy plate supplies occurs at a time fast becoming known as The Alloy Age. "Technological advances . . . in petroleum refining, chemicals, petrochem-

Reduce your liquid handling costs!

Install JOHN CRANE



TYPES 1 and 2
ALCOHOLS
GENERAL CHEMICALS
LIGHT HYDROCARBONS
MANY ACIDS
REFRIGERANTS



TYPE 9
EXPENSIVE CHEMICALS
CORROSIVES
FLAMMABLE LIQUIDS
SOLVENTS
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MECHANICAL SEALS

There is no better way to cut liquid handling costs than with "John Crane" Seals. They are specially engineered for the Chemical Industry to provide these important operational savings:

1. Eliminating loss of expensive and corrosive fluids.
2. Positive sealing of toxics, thus minimizing need for costly exhaust equipment.
3. Substantially reduced maintenance and the man-hours involved.
4. Reduction of "shutdown periods" due to materially increased service-life expectancy over and above your present methods.

Ranging from the Types 1 and 2 (for services where synthetic rubber is suitable) to the Type 9 (with sealing members made of DuPont Teflon to handle any industrial chemical or corrosive) . . . there is a "John Crane" Seal that can be adapted to your individual conditions.

remember: Your toughest problem can be "John Crane's" next success story.

Don't wait, call us now. Get our seal catalog . . . . .

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JOHN CRANE CRANE PACKING COMPANY
38 YEARS INDUSTRIAL PROGRESS
OFFICES IN ALL PRINCIPAL CITIES

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening . . .

icals, for example," Huston said, "are boosting operating temperatures and pressures and raising corrosion problems which must be met by increased tonnages of quality alloy and clad steels in plate gages. Supplying the new varieties of steel plate that make progress possible has now become a prime duty of the industry. In addition to their anticipated growing markets over the long haul, these alloys and clads when properly applied also serve as a means for relieving the current shortage of heavy plate."

To Sponsor Fellowships

The Lead Industries Association will sponsor a fellowship in the Department of Ceramic Engineering, University of Illinois for the academic year 1957-1958 for research on lead in ceramics. The work will be under the direction of Professor Andrew I. Andrews, head of the department. The current great interest of the ceramic industry in the low temperature firing characteristics of ceramics made with lead has motivated this action on the part of the lead industries, which is in addition to a similar grant recently made to the School of Ceramics at Rutgers.

LPG Stocks Show Decline

Underground stocks of liquefied-petroleum gases on November 30, 1956, totaled 532 million gallons, a decrease of 33 million gallons during the month, according to the Bureau of Mines.

Of the total, 436 million gallons were concentrated in Alabama, Mississippi, Louisiana, Texas, and New Mexico, and the rest was distributed through New York, Michigan, Illinois, Kansas, Oklahoma, and Montana.

Underground stocks of propane totaled 389 million gallons, a decrease of 7 million gallons; butane 128 million gallons, a decrease of 25 million gallons, and butane-propane mixture 15 million gallons, showing no change.

WHY CONSIDER UNIFLUX?

FOR LOWER COST? . . . . . YES!
(25% to 50% Lower)

FOR COMPARABLE CAPACITY? . . . . YES!
(Equal or Better Than Conventional Designs)

FOR HIGHER EFFICIENCY? . . . . . YES!
(Closer Approach to Equilibrium)

FOR MAXIMUM FLEXIBILITY? . . . . YES!
(Wide Operating Range)

FOR MINIMUM MAINTENANCE? . . . YES!
(Simplified Installation, Self-Cleaning Characteristics)

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Designers, Builders, Fabricators of Heat Resisting Alloy and Stainless Steel Equipment

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Esso to Use Dow Catalyst

Esso Research and Engineering Co. has signed a license agreement to use The Dow Chemical Co.'s catalyst and process for making butadiene, one of the two major ingredients of GRS-type rubber.

The license may be made available to affiliates of Esso Research world-wide. Esso Petroleum, Ltd., British affiliate, plans to use the process at its new butadiene manufacturing facilities in Fawley, England, which are expected to be in operation in 1958.

The Dow process and catalyst have been in the commercial development stage for several years at the Polymer Corp., Canadian synthetic rubber plant at Sarnia, Canada.

This Dow catalyst is a calcium nickel phosphate material. Its use in butadiene production represents approximately a 20 percent increase in production efficiency over other catalysts now in use. Dow also estimates that considerable savings in capital and plant equipment will result from its use. With modification of equipment, the catalyst can be used in butadiene manufacturing plants now in operation.

Claims Fast Shuffle from AF

Asphalt Institute has claimed that the Air Force used a "one short" 1956 paving test to disqualify asphalt pavements on heavy bomber airfields.

President J. E. Buchanan said the B-47 traffic conditions called for a six-fold increase in standard coverages but the asphalt section was subjected to an increase of 20 times the regular test traffic under consistently hot pavement conditions.

Buchanan added that for such an unprecedented and unrealistic test pattern there should have been a proportionate reduction in the asphalt content of the paving mixture, a fact which was recognized by the Corps of Engineers but who were powerless to act under the terms of the test imposed by the Air Force.

Octane Ratings Dip Slightly

Gasoline on sale at service stations in February showed national weighted averages of 97.3 octane number for premium and 90.4 octane number for regular, according to the latest monthly survey of antiknock quality compiled by Ethyl Corp.

Both the premium and regular averages were 0.1 octane numbers below their January level. Compared with a year ago, the premium average was 0.9 octane number

For more data on advertised products, use Readers' Service Cards, last page.

MULTIGRIP Floor Plate for safety and service in Shell refinery

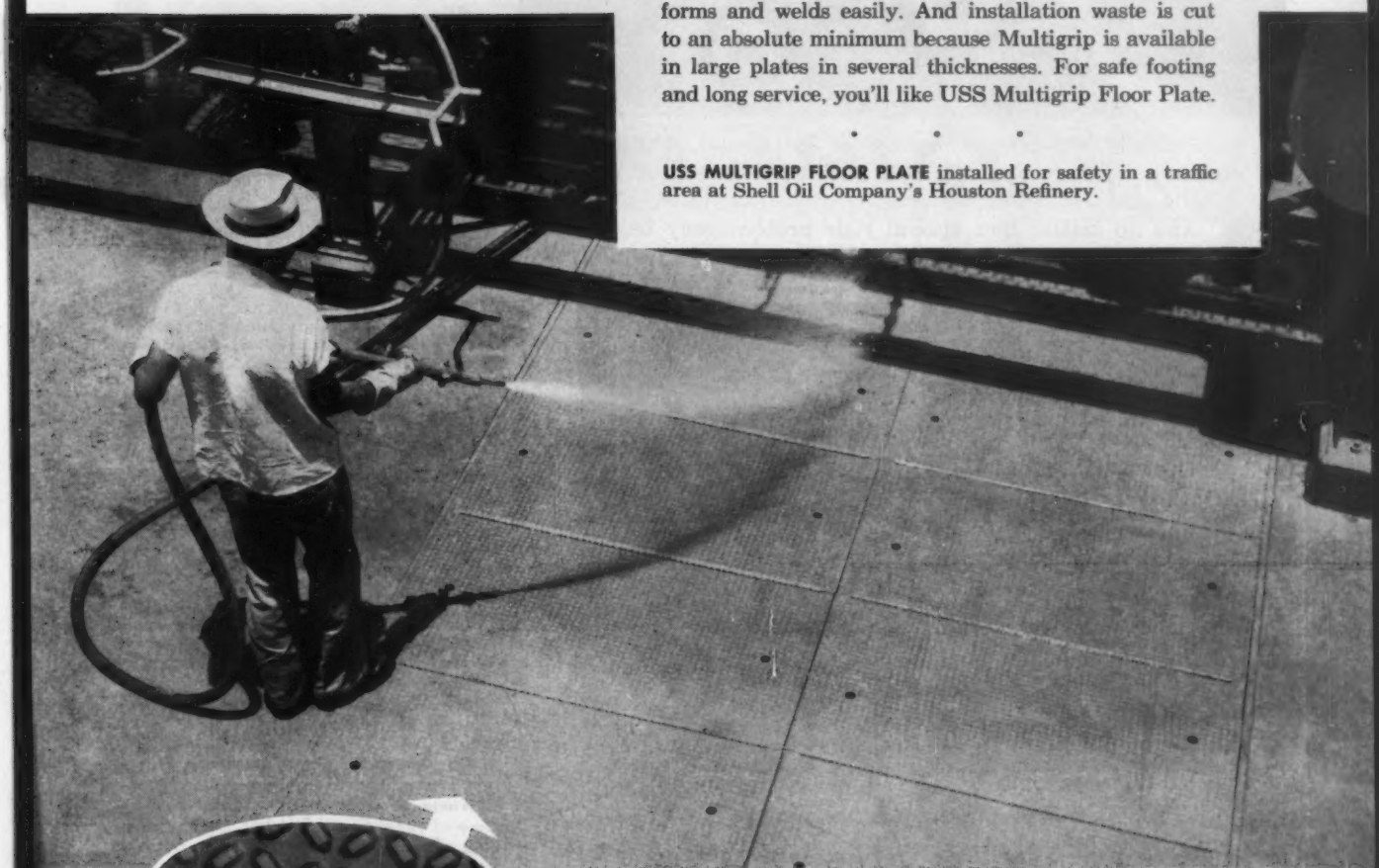
Safety and durability are key factors in all refinery traffic areas. Catwalks, ladders, ramps and walkways that are in use around the clock *can* be real accident hazards as well as maintenance headaches. Avoid these problems by using USS Multigrip Steel Floor Plate.

Made from tough steel, Multigrip is built to stand up under years of punishment without chipping, cracking or splintering. Evenly spaced risers have clean edges, and flat tops that provide positive traction—from all directions. The risers' flat tops mean more comfortable footing, too. Cleaning? As the photograph illustrates, there's no problem there. A hose or broom is all it takes to keep Multigrip clean.

Installing Multigrip is never a problem. It cuts, bends, forms and welds easily. And installation waste is cut to an absolute minimum because Multigrip is available in large plates in several thicknesses. For safe footing and long service, you'll like USS Multigrip Floor Plate.

• • •

USS MULTIGRIP FLOOR PLATE installed for safety in a traffic area at Shell Oil Company's Houston Refinery.



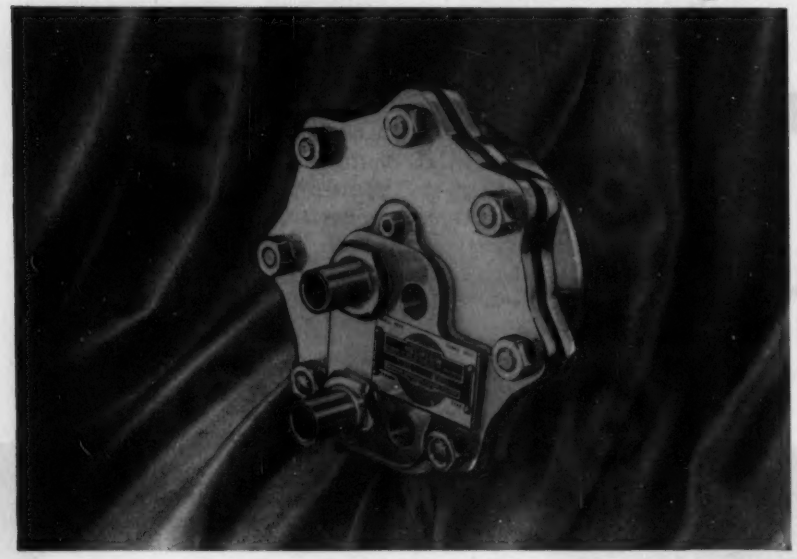
UNITED STATES STEEL CORPORATION, PITTSBURGH
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, CHICAGO
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **multigrip**
FLOOR PLATE

Sold by leading distributors from coast to coast

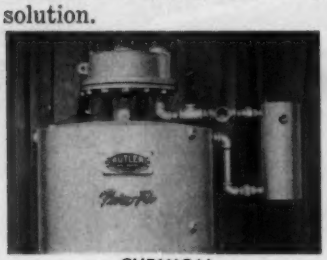
UNITED STATES STEEL

The SOLID GOLD Heliflow® Heat Exchanger

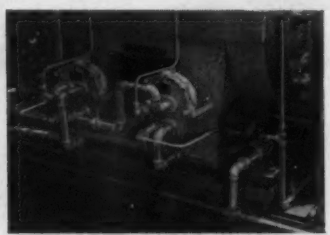


Actually we've never built one. But should your heat exchanger job require it, HELIFLOW® *can* be built of gold —solid gold.

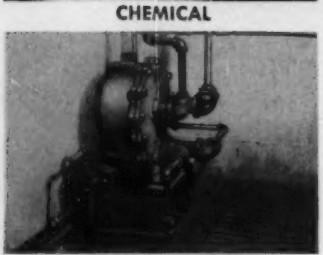
And no matter how special your problem may be, the chances are that HELIFLOW® will offer the most favorable solution.



CHEMICAL



GLAND SEAL COOLING



WATER HEATING

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—AND A THOUSAND OTHER USES!

May we quote HELIFLOW® for your heat exchanger job?

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What's Happening . . .

higher, and the regular average was 1.2 octane numbers higher.

Average tetraethyl lead contents in February were 2.47 ml per gallon of premium gasoline and 2.02 ml per gallon of regular gasoline.

Twenty-two of the 53 cities in Ethyl's survey reported increases over January in the average octane number of their premium gasoline. Twenty-one cities reported decreases while ten cities remained unchanged. In regular gasoline, 17 cities reported increases over January in their average antiknock quality, one of them by 0.5 octane number. Twenty-two cities reported decreases, and 14 cities were unchanged.

Compared with the nationwide premium average of 97.3 octane number, 12 cities reported premium averages of 98 octane number or higher. In regular gasoline, 17 cities showed average octane ratings of 91 octane number or higher, compared with the national weighted average of 90.4 octane number.

Ethyl's survey is based upon approximately 850 gasoline samples purchased each month at service stations in the 53 marketing centers.

Changing Times

Fire and explosion in a 5000 bpd sulfuric alkylation unit **at Indiana-Standard's Whiting** refinery injured seven and caused $1 million damage. **Cause of the blast: unknown.** Company will assume the $1 million loss under its $1 million deductable policy.

House has passed and has sent to Senate, legislation authorization for **sale of government-owned alcohol-butadiene plant** at Louisville, Ky.

Esso Standard and Firestone Tire are among nine American firms using Salk vaccine to build good will in overseas communities. With only a couple of exceptions, native children are given the standard three shot treatment whether or not their parents are company employes. Polio incidence in these countries is particularly high among children, and mass innoculation program cannot be financed. Result: tremendous public relations gains.

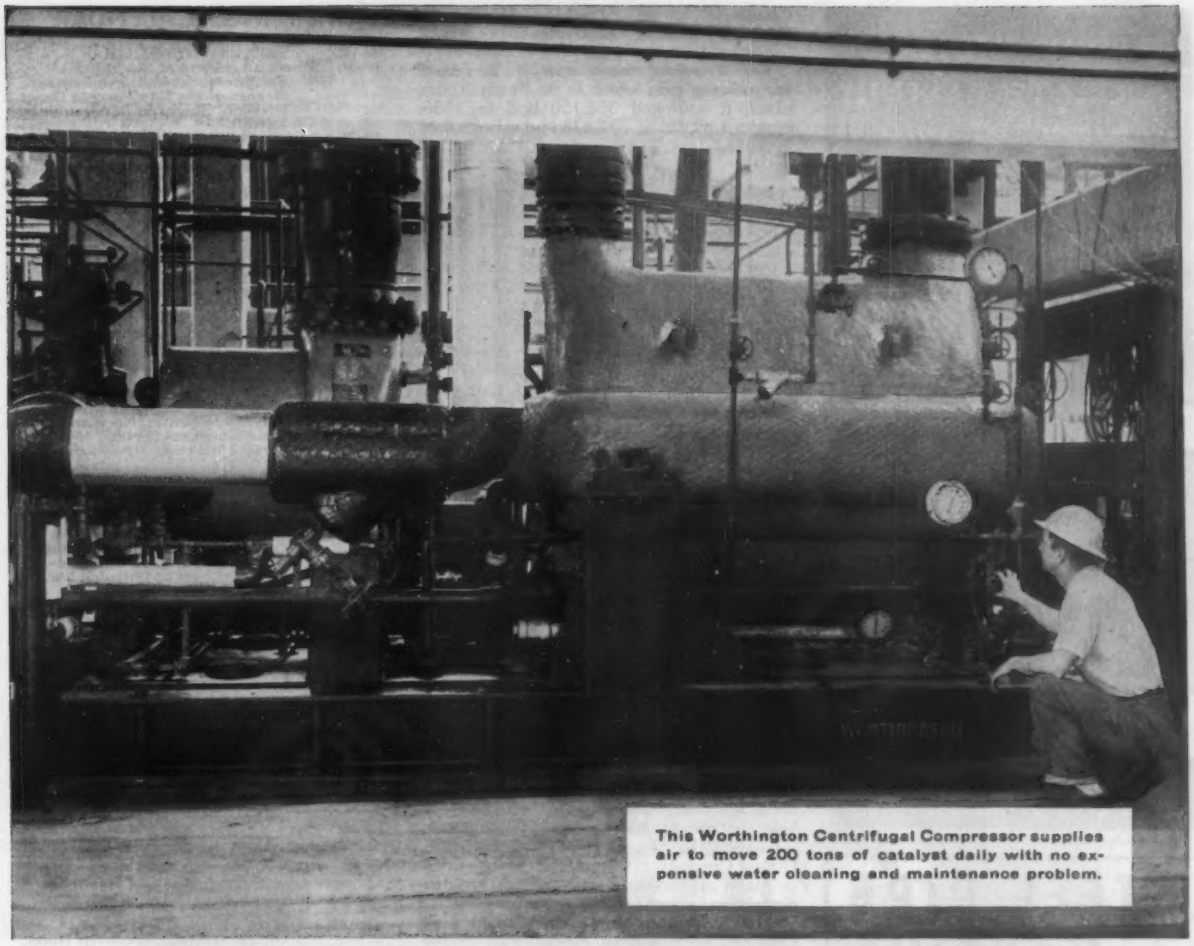
Identical bills which would require motor fuels to contain minimum of 5 percent alcohol produced from farm products have been introduced in Senate and House by Senator Mundt (R-S.D.) and Representative Jensen (R-Iowa).

Oil Centennial Corp., a nonprofit organization, has been chartered in Pennsylvania to commemorate 100th anniversary of the industry in 1959. Organization will accept donations to promote celebration activities. Petition for charter was presented by 16 Pennsylvania oil men.

Sunset International Petroleum's Torrance, Calif., refinery was shut down recently following fire in cracking unit heater. Split tube in the heater was believed to be the cause.

Gulf Oil Corp. has created one new foreign subsidiary and has changed the name of another. New: Gulf Oil Co. of Libia.

For more data on advertised products, use Readers' Service Cards, last page.



This Worthington Centrifugal Compressor supplies air to move 200 tons of catalyst daily with no expensive water cleaning and maintenance problem.

Process compression without diaphragm and water supply problems

Perhaps your processing can be compared to this operation at Cities Service Refining, where heavy gas oils are catalytically cracked into fuel gas, propylene, and butylene for alkylate and butadiene production, high octane gasolines, and light fuel oils.

Here's an example of low-cost, high-volume processing, with a Worthington GUR centrifugal unit compressing the air to move 200 tons of catalyst per day in a trouble-free, economical manner.

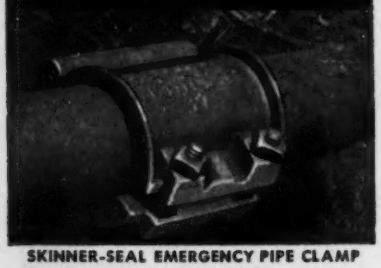
The costly diaphragm and exchanger maintenance problem inherent in the operation of an ordinary compressor is unknown with the Worthington GUR. At Cities Service's Lake Charles refinery, the Worthington centrifugal operates with 95° F. air at 100% relative humidity and 14.5 psia suction pressure, and discharges at 61 psia, 450° F., with a capacity of 4,875 CFM. The compressed air is used to transfer and aerate the catalyst. The temperature of the compressed air is controlled by means of interstage liquid injection, an exclusive development that reduces the heat of compression without employing external heat exchangers. It is powered by a dependable Worthington steam turbine. Cities Service reports, "Governing and control are excellent, and in all other respects it is very satisfactory."

If you'd like the same satisfaction for your process compression or refrigeration, write your Worthington District Office or Worthington Corp., Air Conditioning and Refrigeration Division, Section A6101, Harrison, New Jersey.

A-6-101

WORTHINGTON

TO REPAIR PIPE LEAKS—
QUICKLY, PERMANENTLY
ANY PRESSURE — ANY TEMPERATURE



SKINNER-SEAL EMERGENCY PIPE CLAMP
for pinhole or corrosion leaks.

SKINNER-SEAL PIPE LINE CLAMP for
long splits and bad corrosion leaks.

In stock—all supply stores

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ALL SPECIFICATIONS – ANY SIZE
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Milwaukee and Twin Cities—Denver New Orleans

Changed: from Maschinenoel Import G.m.b.H., to Gulf Oil (Germany) G.m.b.H.

Esso Standard set a new U. S. record for refinery runs when at its Baton Rouge plant, it averaged 304,150 bpd in 1956. Previous record of 282,478 bpd was reached in 1955.

Esso Research & Engineering has licensed Dow's butadiene process. First to use it will be Esso Petroleum at Fawley, England. Start-up is scheduled for 1958. Jointly developed by Polymer and Dow, the process is now being used at Polymer's Sarnia synthetic rubber plant.

Ingram Oil & Refining has shifted its headquarters from Nashville to New Orleans to centralize operations. Company operates 10,000-bpd refinery at Chalmette, La.

Democratic majority has ready for introduction in Colorado legislature, **proposed constitutional amendment for severance tax on oil and gas.** Proposal would replace present graduated income tax on oil and gas that has been attacked in courts by major oil companies. If passed by legislature and voters, amendment will place **no limit on severance tax** which will be fixed by legislature.

The last of the oil companies departed from the candlemaking business when Indiana-Standard sold its business to Candle-Lite, Inc. . . . man-made ponds for temporary storage of water and other liquids are providing **giant outlet for high-pressure polyethylene film** . . . a British trade journal has estimated that by 1960, **5 British firms will be producing 260 million lbs./year of polyethylene** (or "polythene" as it's called there) . . . in a surprise move, House Commerce Committee has decided to make preliminary **study of world-wide petroleum supply-demand situation** . . . California Standard is presently testing gasolines with **octane rating well above 100 level . . . Gulf Oil Will make its third and higher octane** gasoline available very shortly.

Changes In Ownership

Panhandle Eastern Pipe Line Co. has reached out to another phase of the oil industry by purchasing Century Refining Co., Inc. In the deal, Panhandle gets a 6000 bpd refinery at Shallow Water, Kans. The firm is active in exploration and production, and also manufactures petrochemicals through National Petrochemical Corp.

Keta Gas & Oil Co. has been purchased from Swan-Finch Gas Development Co. by Doeskin Products, Inc., the facial tissue manufacturer. Basis of the deal was exchange of stocks.

Husky Oil & Refining Ltd., has been completely acquired by Canadian Husky Oil., Ltd., in a stock exchange deal. No changes are contemplated except that Husky Refining will now shove Canadian in front of its name.

The Newly formed Kirby Vensyn Petroleum Co. has acquired the assets of Kirby Oil & Gas Co. and Venezulean Syndicate, Inc. It has also taken over many of the properties held by the C. W. Murchinson family of Dallas. Murchinson trusts will hold about 20 percent of the stock of the new company while Kirby Oil and Venezuela will be dissolved.

MEETINGS CALENDAR

MAR.	
18–21	American Society of Mechanical Engineers, Second National Conference of the Gas Turbine Power Division, Sheraton Cadillac Hotel, Detroit.
18–21	Society of Plastics Industry, Annual Conference and Pacific Coast Plastics Exposition, Shrine Exposition Hall, Los Angeles.
25–27	Western Petroleum Refiners Association 45th Annual Meeting, Hilton Hotel, San Antonio, Texas.
25–29	Tenth Western Metal Exposition and Congress, American Society for Metals and Other Technical Groups. Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles.
27–29	American Power Conference, Annual Meeting, Sponsored by Illinois Institute of Technology, Hotel Sherman, Chicago.
APRIL	
2– 4	Corrosion Control Short Course, University of Oklahoma Extension Study Center, Norman.
7–12	American Chemical Society, 131st Annual Meeting, Miami, site unreported.
8–10	The American Society of Mechanical Engineers, Spring Meeting, Din kler-Tutwiler Hotel, Birmingham, Ala.
8–12	American Welding Society, Spring Technical, National and Welding Show, Sheraton and Bellevue-Stratford Hotels, Philadelphia.
9	"Catalysis in Practice" Meeting, AIChE Philadelphia-Wilmington Section, University of Pennsylvania Museum, Philadelphia.
9–11	Fifth Welding Show Sponsored by American Welding Society, Convention Hall, Philadelphia.
16–18	National Petroleum Association, Semi-Annual Meeting, Cleveland Hotel, Cleveland.
19	Association of Consulting Chemists and Chemical Engineers Symposium Belmont Plaza Hotel, Baroque Room, New York City.
24–26	National Gasoline Association of America, 36th Annual Convention, Rice Hotel, Houston.
25–26	The American Society of Mechanical Engineers, Conference on Management, Statler Hotel, New York.
28–30	Independent Petroleum Association of America, Midyear Meeting, Buena Vista Hotel, Biloxi, Miss.
29–May 1	American Oil Chemists' Society Annual Meeting, Roosevelt Hotel, New Orleans.
MAY	
3	Fourth Annual Conference of Engineers and Architects, College of Engineering, Ohio State University.
13–14	Commercial Chemical Development Association, Resort Meeting, French Lick, Ind.
13–16	American Petroleum Institute Division of Refining, Midyear Meeting, Sheraton Hotel, Philadelphia.
14–16	Industrial Nuclear Technology Conference, Museum of Science and Industry, Chicago.
19–23	The American Society for Mechanical Engineers, Oil and Gas Power Conference, Kentucky Hotel, Louisville, Ky.
23–24	Western Petroleum Refiners Association, Southwest Regional Technical-Industrial Relations Meeting, Hotel Paso del Norte, El Paso, Texas.
JUNE	
6	Pennsylvania Grade Crude Oil Association, 34th Annual Meeting, Penn-Sheraton Hotel, Pittsburgh, Pa.
9–12	American Institute of Chemical Engineers, Olympic Hotel, Seattle, Washington.
14–16	The American Society of Mechanical Engineers, Semi-Annual Meeting, Sheraton-Palace, San Francisco.
16–21	American Society for Testing Materials, Annual Meeting, Chalfonte-Haddon Hall, Atlantic City, N.J.
19–21	Twelfth Annual Meeting for Association for Computing Machinery, University of Houston.
20–21	Western Petroleum Refiners Meeting, Mid-Continent Regional Technical-Industrial Relations Meeting, Broadview Hotel, Wichita, Kan.
24–28	American Institute of Electrical Engineers, 1957 Fall General Meeting, Sheraton-Mt. Royal Hotel, Montreal, Canada.

For more data on advertised products, use Readers' Service Cards, last page.

GAUGE HATCHES
Available for cone roof, floating roof and low pressurized storage tanks, featuring positive tightness, automatic closure, and resilient cover seal.

FREE VENTS
Sturdy, screened units that provide unimpeded free flow of air and vapor in and out of tanks.

BREATHER VENTS
For low pressure storage of both the working and emergency type, incorporating diaphragm seals for positive tightness.

ANNOUNCING Wheaton *precision* TANK FITTINGS

WATER DRAIN VALVES
New designs incorporate steel bodies, with resilient seats.

AUTOMATIC TANK GAUGES
Incorporate Neg'ator spring in gauge head with high visibility tape with new design tubular float. Applicable to all low pressure storage tanks.

Precision is the hallmark of Wheaton Tank Fittings — developed through 65 years experience in the manufacture of equipment for the handling of petroleum and chemical products. Wheaton Precision is your assurance of quality. *Send for Catalog No. 66, which illustrates and describes the complete line of Wheaton Tank Fittings.*

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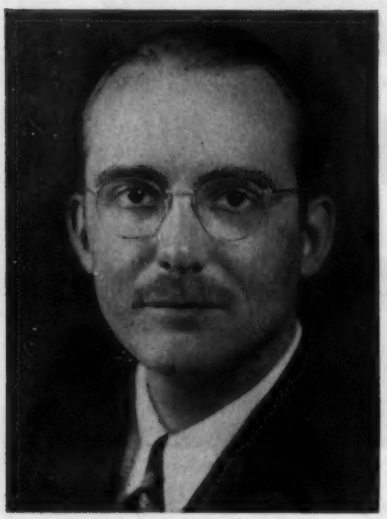
What's Happening . . .

. . . *Among Men* in the Industry

Dr. Charles L. Thomas Elected Director-at-Large for ACS

Dr. Charles L. Thomas, director of research and development of the Sun Oil Co., Marcus Hook, Pa., has been elected a director-at-large of the American Chemical Society. Dr. Thomas will serve on the board through 1958, completing the unexpired term of Dr. Clifford F. Rassweiler, who became a director ex-officio when he was named president-elect of the society.

A leader in developing improved gasolines, Dr. Thomas was co-inventor of a highly efficient synthetic silica alumina catalyst used to make gasoline from petroleum. First used on a wide scale during World War II in the production of aviation gasoline, it is now extensively employed in making motor fuel. He holds more than 100 U. S. patents and has written many articles on petroleum chemistry.



Dr. Charles L. Thomas

A native of Hendersonville, N. C., Dr. Thomas attended the University of North Carolina, where he received his B.S. degree in 1928 and his M.S. degree in 1929. He earned the Ph.D in 1931 at Northwestern University.

He joined Universal Oil Products Co., Des Plaines, Ill., in 1931 as research chemist and associate director of research. He left in 1945 to become director of research at the Great Lakes Carbon Corp., Morton Grove, Ill., remaining until 1951. Then he joined Sun Oil where he has played an important role in guiding the company's research and development on custom blended gasolines.

For his contributions to petroleum chemistry and to the advancement of the chemical profession, Dr. Thomas recently received the annual Honor Scroll Award of the Pennsylvania Chapter of the American Institute of Chemists. During his 30-year membership in the American Chemical Society, Dr. Thomas has been head of the Society's Chicago Section and vice-chairman of the ACS Division of Petroleum Chemistry. He also has been chairman of the ACS Committee on Constitution and Bylaws and has served on the advisory boards of two publications of the Society.

Dr. Thomas also is a member of the American Institute of Chemical Engineers, the American Institute of Chemists, the American Petroleum Institute and the Society of Automotive Engineers.

Robert M. Woolfolk, Jr. has joined Texas Gas Corp. as chief engineer. A graduate of Tulane University with a B.S. degree in chemical engineering, Woolfolk's headquarters will be at the Houston general offices of Texas Gas Corp. Before becoming associated with Texas Gas, Woolfolk held a similar position with The California Co.

Edward Oliphant, Jr., has been promoted to group leader at the Standard Oil Co. (Indiana) Sugar Creek, Mo., research department laboratory. Oliphant, a graduate of the Missouri School of Mines with a B.S. degree in chemical engineering, has been with Standard Oil since 1952. He is a native of Richmond, Mo.

Roy J. Diwoky has joined Commonwealth Oil Refining Co. and will be located in Ponce, Puerto Rico, where the company's 23,000-bpd refinery expects to complete an expansion in capacity to 53,000 bpd by July, 1957. Diwoky recently resigned as general manager and a director of American Oil Co. after 20 years' service with Standard Oil Company (Indiana) affiliates including Amoco. A native of Council Bluffs, Iowa, and a graduate of the University of Iowa, Diwoky will be proposed for election as a director of Commonwealth at the annual stockholders' meeting.

Diwoky

Copeland

Bailey

William G. Copeland has been appointed general manager of The Texas Co.'s Refining department. Manager of the Refining department's operations division since January, 1956, Copeland succeeds **Theodore A. Mangelsdorf,** who recently was elected a vice president. **Douglas P. Bailey,** assistant works manager of the company's Port Arthur refinery since 1945, succeeds Copeland as manager of operations in New York.

Graduated from Rice Institute with a B.S. degree in chemical engineering in 1927, Copeland joined Texaco that year as a chemist at Port Arthur. He has served as assistant superintendent of the company's Lawrenceville, Ill., Works and as superintendent of the Sunburst, Mont., and Westville, N. J., refineries.

Bailey graduated from the University of Texas in 1922 with a B.S. degree in chemical engineering and joined Texaco as a chemical engineer at Port Arthur in 1927.

Joseph T. Froehlich has been named superintendent of The Texas Co.'s new Anacortes, Wash., refinery. Froehlich, who has been a superintendent with special assignments in the refining department's headquarters in New York since last September, graduated from Cornell University in 1929 with a B.S. degree in civil engineering. He joined Texaco that year as a draftsman in the refining department in New York.

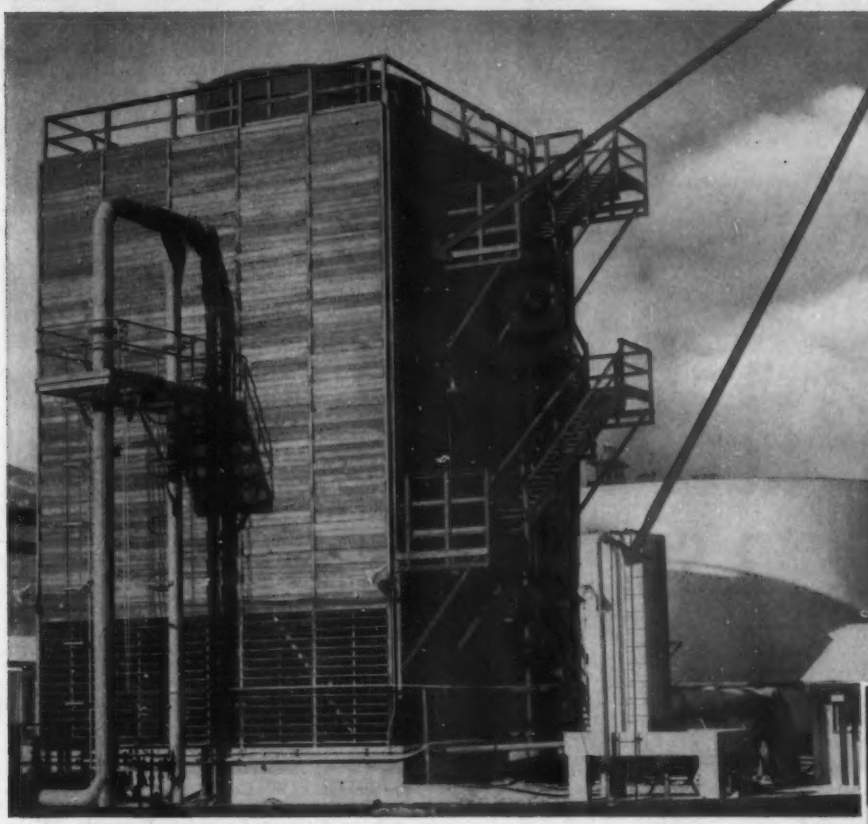
J. L. Tathwell, formerly chief project engineer and **F. G. Crawford,** formerly manager of project coordination, have been promoted to the new position of manager of projects for The Fluor Corp., Ltd.

The new executive posts were created to strengthen the management direction of Fluor projects. All present and future active contracts will be assigned to a manager of projects for overall management and coordination.

C. L. Parris, chief engineer at the El Dorado, Ark., refinery of the American Oil Co., has been named manager of the new plant for the midwest area for Amoco Chemicals Corp.

Entering the engineering department of Standard Oil Company (Indiana) at Whiting, Ind., in 1942, Parris became a supervisor in that department in 1947. He

TESTING—1, 2, 3



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is your assurance of
higher cooling efficiency and long tower life

OVER 40 years of experience notwithstanding, *research* continues to play an important part in Foster Wheeler cooling tower work. Latest addition to FW cooling tower research facilities, is the fully equipped test center shown above. Here every detail of design is subjected to exhaustive and precisely measurable tests under conditions identical to those encountered in actual service. In addition to proving the superior thermal and mechanical design of FW Cooling Towers, this research is continually helping to develop new and improved construction methods and materials, for higher performance standards and longer cooling tower life.

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1 Large Commercial Size Cooling Tower, 30' by 30' ground area and 44' height, with removable casing panels for testing of various materials. Includes provision for measuring temperatures, pressures, water and air flow throughout the tower, with the ability to vary these conditions over a wide operating range.

2 Small-scale Pilot Tower for preliminary exploration.

3 Complete Indicating and Recording Instrumentation facilities for precise measurement of all tower test and psychrometric data.

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FOUNDER MEMBER CTI COOLING TOWER INSTITUTE

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Men in the Industry . . .

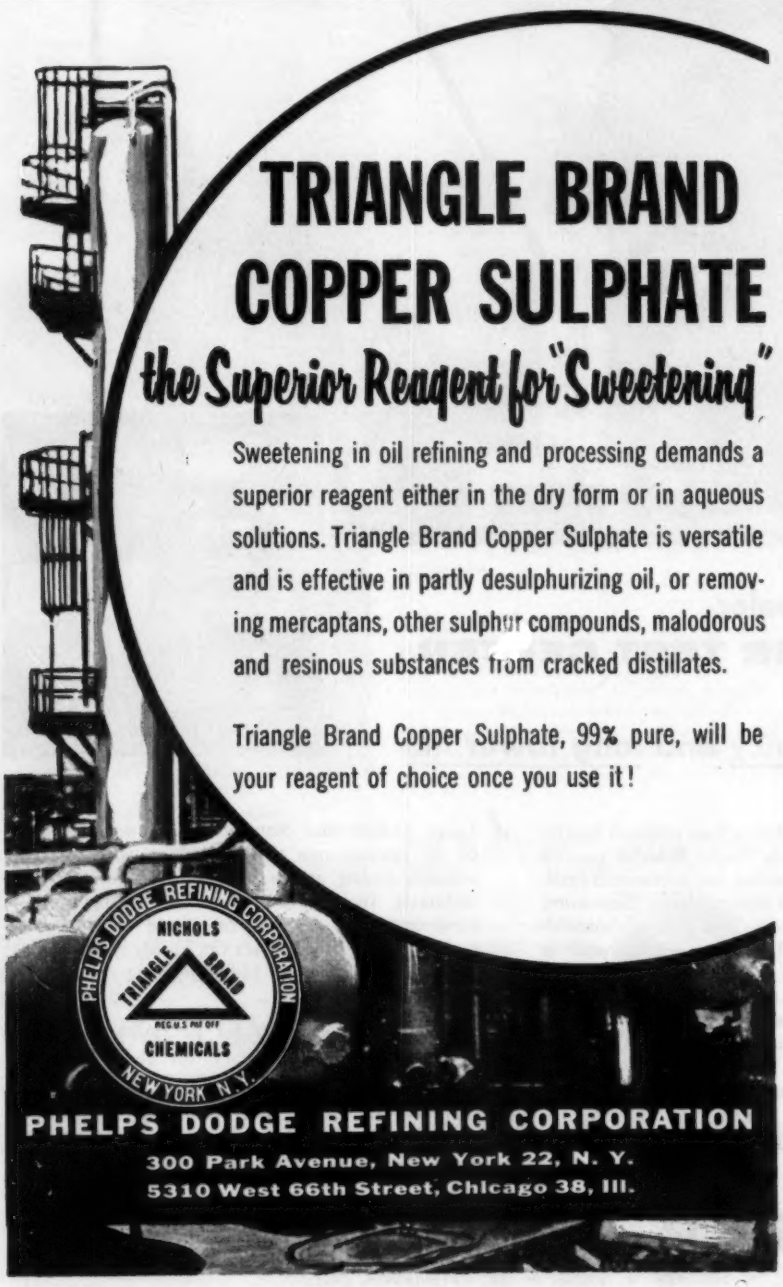
was named chief engineer at El Dorado in 1950. Parris is a graduate in civil engineering of Texas Technological College and holds an M.S. degree in civil engineering from Illinois Insitute of Technology.

Richard H. Travis has joined the staff of David G. Reynolds, Process Unit Designs, as chief instrument engineer. Travis has had 15 years continuous experience with major process-designer contractors and refiners previous to his present position.

Dr. Zay Jeffries, metals scientist and retired vice president of the General Electric Co., has been re-elected chairman of the board of trustees of Battelle Institute, Columbus, Ohio.

Retaining positions on the Battelle board of trustees with Jeffries are **Gerald B. Fenton,** first vice chairman and treasurer; **Harry M. Runkle,** second vice chairman; **J. C. Miller; Clyde Williams,** Battelle president; and **Dr. Roger Adams,** past president of the American Chemical Society.

Newly elected Institute secretary is **E. E. Slowter.** He will continue also to serve as business manager and assistant treasurer. Reappointed as vice presidents were **Dr. B. D. Thomas,** the Institute's new Director; **David C. Minton, Jr.;** and **John S. Crout.**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Sweetening in oil refining and processing demands a superior reagent either in the dry form or in aqueous solutions. Triangle Brand Copper Sulphate is versatile and is effective in partly desulphurizing oil, or removing mercaptans, other sulphur compounds, malodorous and resinous substances from cracked distillates.
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C. D. Haxby, vice president, The Rust Engineering Co., Pittsburgh, has been elected president of the National Constructors Association. **Carl B. Whyte,** president, Procon Inc., Des Plaines, Ill., was elected vice president. New members of the executive committee, in addition to the officers, are **Paul L. Wetcher,** manager, labor relations, C. F. Braun & Co., Alhambra, Calif.; **W. B. Poor,** vice president, Ford Bacon & Davis Construction Corp., Monroe, La.; **Paul S. Klick, Jr.,** personnel director, Foster Wheeler Corp., New York; **H. A. Denny,** vice president, Koppers Co., Inc., Pittsburgh; and **D. S. Pelletier,** partner, Sanderson & Porter, New York.

L. G. (Gayle) Rodgers, general manager of the Gas division of Sunray Mid-Continent Oil Co.'s Production department, has been granted a one-year leave of absence to serve with the Oil and Gas Division of the U. S. Department of the Interior in Washington, D. C.

Rodgers

H. A. Stewart, director of the Interior department's Oil and Gas division, said Rodgers was requested by the government to serve as commodity industry analyst with the operating title of refining technologist.

R. E. Foss, vice president in charge of production for Sunray, said Rodgers will retain his company position while on loan to the government and that his duties will be distributed among other members of the production department staff during his absence.

Harry Jeffries was elected a director of Sinclair Oil Corp. and executive vice-president-administration, the latter being a newly created position. Formerly Jeffries was a vice president. As a director he succeeds **A. E. Watts,** who has resigned. **E. L. Steiniger,** a former vice president and already a director of Sinclair Oil Corp. has been elected to the newly-created post of executive vice president-operations. **C. J. Allen,** executive vice president of Sinclair Refining Co., has been elected vice president, Sinclair Oil Corp., and will serve as administrative assistant to **P. C. Spencer,** president. **W. H. Morris,** former president of Sinclair Pipe Line Corp. was elected vice president of Sinclair Oil Corp. and will serve as executive assistant to Steiniger in operations. **O. P. Thomas,** former assistant comptroller has been elected vice president and will be executive assistant to Jeffries in administration.

C. E. Evans has been named general manager of British Hydrocarbon Chemical Co., Ltd. Evans has been with the company since October, 1951 as manager of the Grangemouth, Scotland, plant. His career with BP companies began in 1939, culminating as works manager of the Abadan refinery. He holds the Order of the British Empire.

D. Blair Watt has been named works manager of the Grangemouth plant.

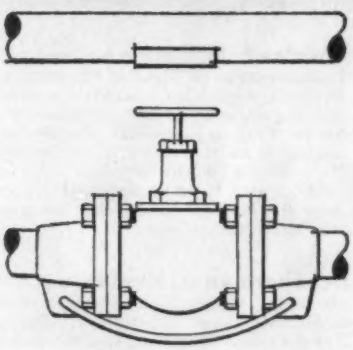
Karl G. Krech has been named general manager of the crude oil purchases and sales department of The Atlantic Refining Co. in Philadelphia, succeeding **C. W.**

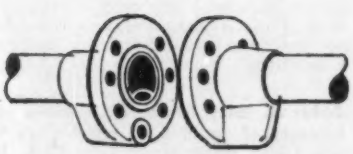
With this new round shape, UNITRACE costs substantially less per foot. And since the steam passage has less outside wall area, external radiation heat loss is reduced. The need for thermal insulation is often eliminated. When insulation is used, it costs less because standard pre-formed pipe covering can be used.

to cut costs,
boost efficiency
of steam traced pipe...

ALCOA UNITRACE has a NEW SHAPE

for lower cost per foot...
easier joining...
less heat loss...better
internal heat transfer





Sections of UNITRACE in the new shape can be easily and quickly joined by the weld and patch method (top). And a brand new UNITRACE flange—with product and steam passages cast as integral parts of the flange—simplifies installation of valves (center) and other flanged connections (bottom).

Want to save money on steam-traced piping? Here's good news for your pocketbook! ALCOA® UNITRACE *has a new cost-cutting shape* . . . a round section matching standard pipe shapes . . . available in 1½", 2", 3" and 4" sizes.

With steam and product passages extruded in a single unit of light, strong, corrosion-resistant Alcoa aluminum alloy 3003-F, UNITRACE completely eliminates the cost of external steam jackets or tracer tubes. And the new UNITRACE shape makes possible these *extra* savings:

Lower cost per foot . . . total volume of metal is less; material costs are lower.

Easier, faster joining . . . new configuration (with exterior grooves for quick steam passage identification) makes mating and joining fast and simple to cut installation costs.

Less external heat loss . . . improved internal heat transfer . . . the new design reduces area for external radiation loss.

The natural corrosion resistance of aluminum makes UNITRACE ideal for handling naval stores, molten sulfur, ammonium nitrate solutions, glacial acetic acid, fatty acids, tar, pitch, wax, urea and similar products which normally require heated transfer lines.

Find out today how *you* can use ALCOA UNITRACE to cut costs and improve efficiency of your heated transfer lines. Call your nearest Alcoa sales office, or write Aluminum Company of America, 905-C Alcoa Building, Pittsburgh 19, Pennsylvania.

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*All Machines tested to 2,175 p.s.i.

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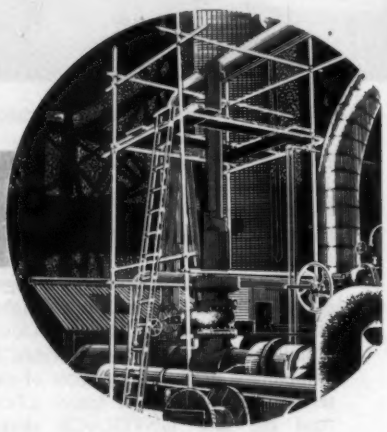
FOR MAKING REPAIRS AND ADDITIONS TO PIPING WHILE FLOW CONTINUES THROUGH TEMPORARY BY-PASS



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Men in the Industry . . .

Stose, who is newly attached to the office of the vice president and general manager of manufacturing. Krech is a Cornell graduate who joined Atlantic at the Philadelphia refinery in 1925.

Oscar John Dorwin has been elected a director of The Texas Co. in New York, succeeding **R. F. Baker,** former executive vice president, retired. Dorwin has been with Texaco since acquisition of the Indian Refining Co. in 1931, of which he was general counsel. He became a vice president of Texaco in 1951, after rising to general counsel in 1944. Also, **Theodore A. Mangelsdorf** was elected a vice president of Texaco. A chemical engineer, Mangelsdorf joined the company in 1933 and later served as superintendent of the Port Arthur, Texas, and Lockport, Ill., refineries. Since July, 1954, he has served as general manager of domestic refining. In his new post, he will fulfill special assignments for the chairman, **Augustus C. Long.**

Dr. John E. Kasch has been elected vice president and a director of American Oil Co in New York. Formerly manager of Amoco's research and development, Kasch has three degrees including a Ph.D. in chemical engineering, all from the University of Texas. He first joined the company in 1942 as a chemical engineer at the Texas City refinery. Later he served the Petroleum Administration for War for two years.

Kasch

Charles F. McMackin has been named superintendent of Stauffer Chemical Co.'s Portland, Ore. plant. McMackin holds a B.S. degree in chemistry and joined Stauffer in 1943 as a control chemist. After serving as an electronics technician in the Navy during World War II, he rejoined Stauffer as a plant engineer. He succeeds **John B. Gay** who has become plant manager at Vernon, Calif.

Dr. Sherman S. Shaffer, staff associate in the technical and research division at Humble Oil & Refining Co.'s Baytown, Texas refinery, has been elected chairman of the American Chemical Society's division of petroleum chemistry for 1957.

Also, **J. H. Craddock,** Humble sales engineer (aviation) has been elected chairman of the Aviation Advisory Committee of the American Petroleum Industries Committee.

John B. Gay has been appointed plant manager of Stauffer Chemical Co.'s Vernon, Calif., plant. He replaces **H. L. Herkelrath** who, for reasons of health, has asked to be relieved of some of his responsibilities but still remains as staff assistant to the plant manager.

Gay joined Stauffer in 1927 as an operator in the Richmond, Calif., carbon bisulfide plant. He holds a B.S. degree in mechanical engineering and has been sulfuric acid plant operator, control chemist,

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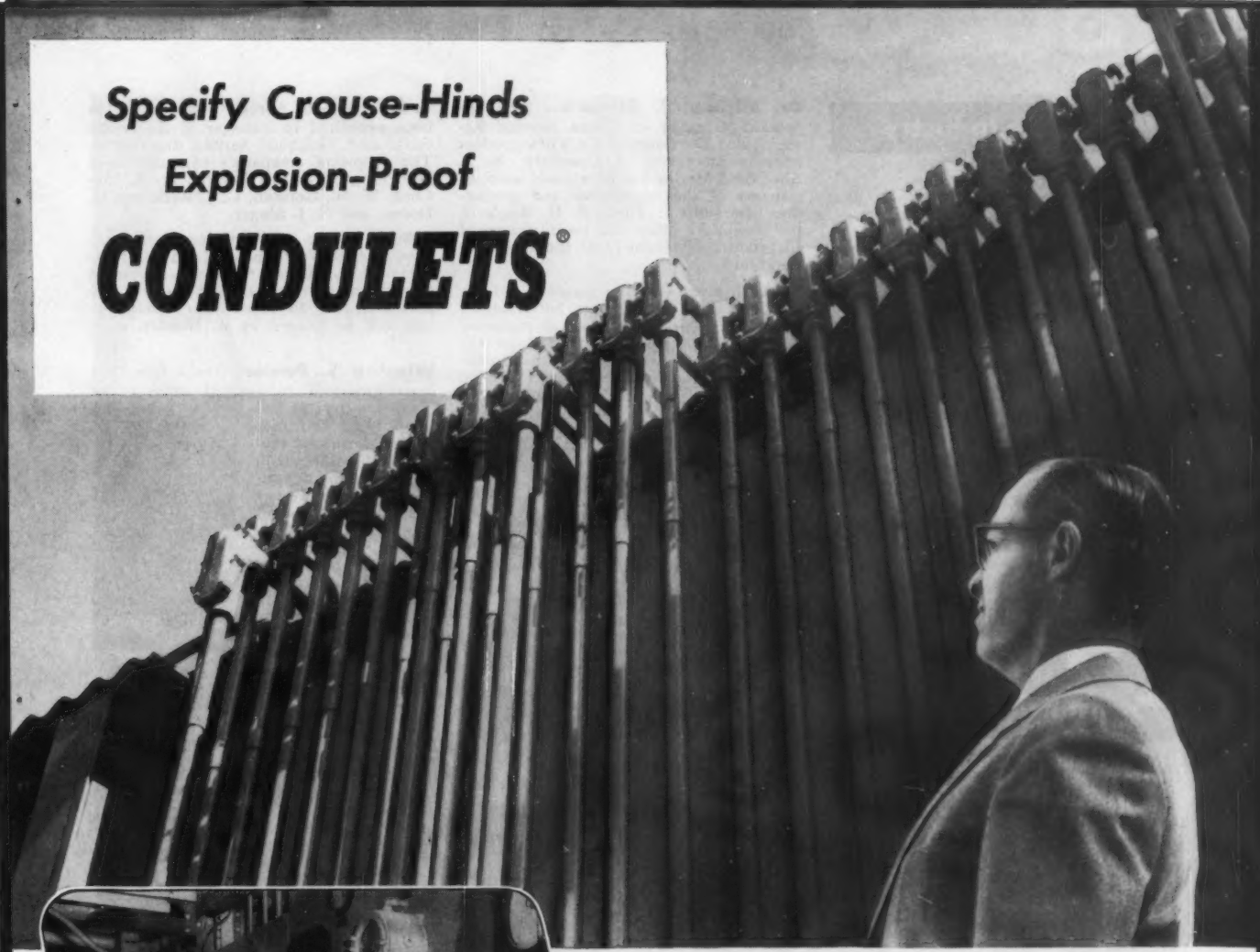

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You'll find Condulet Explosion-proof electrical equipment in the nation's leading plants — from complex instrument enclosures like those on the panelboard (at left), to simple pulling elbows on the branch circuits (above). You'll like Condulet equipment because it installs easily, works right, and stays on the job for years without attention.

There are more than 15,000 Condulet items: conduit fittings, plugs and receptacles, motor controls, lighting fixtures, switches, hundreds of others, both explosion-proof and conventional. Make your selections with confidence. You get the best when you get Condulets.

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Men in the Industry . . .

catalyst researcher, hydrochloric acid plant foreman, and engineer in the San Francisco office.

Arthur V. Danner has been elected president of Mobil Overseas Oil Co. Inc., succeeding **Paul V. Keyser, Jr.**, who will continue as a member of the Mobil Overseas board. Danner was vice president and a director prior to assuming the presidency.

Dr. Michael J. Rzasa has been appointed manager of Cities Service Research and Development Co.'s new product research laboratory at Cranbury, N. J. Also, **Fred Merliss** has been made assistant manager of the exploration and production laboratory at Tulsa. **B. H. Rosen** of the New York office will be in charge of all product development at the Cranbury laboratory.

Dan Milsom is being transferred from the Lake Charles laboratory to Cranbury where he will be in charge of radiation research. For the past year Milsom has been on special assignment at the Brookhaven Laboratory of the Atomic Energy Commission.

T. J. Oleszko, Aurora Gasoline Co., has been promoted to manager of the newly established Technical Service department. The following company's engineers have been assigned to this department: **R. McCord, W. W. Gotshall, C. J. Ryskamp, H. Doron,** and **S. J. Singer.**

R. W. Sheets has been appointed manager of Aurora's Economics and Yield department. **L. Mihaly** has been appointed special engineering assistant to this department, and the department's yield section will be headed by **R. Hendry.**

Winston S. Peeler, Texas City, has been promoted to general manager of manufacturing of American Oil Co. Peeler, formerly general superintendent, administrative department, of the Texas City refinery will make his headquarters in New York and will coordinate the manufacturing operations in the company's six refineries. He succeeds **Roy J. Diwoky,** who resigned recently.

Peeler

Peeler was born in Dallas, and received a B.S. degree in chemical engineering at Rice Institute in 1933. He joined the company in March, 1934 as a chemical engineer in the research and development department. In July, 1952 he became operating superintendent of the company's largest refinery at Texas City, and in 1953 he was made general superintendent, administrative department.

N. B. Latham, general foreman in the Paulsboro, N. J., manufacturing department of the Chemicals division of Houdry Process Corp. has been named superintendent in charge of the Services section.

In the Engineering and Development section, **H. G. Vernon,** mechanical engineering section designer, became plant mechanical engineer. **D. E. Field,** technical assistant to the plant manager, was named plant development engineer.

In the Production section, **W. R. Graves** moved up from shift foreman to production foreman, and was succeeded as shift foreman by **C. A. Bratton, Jr.**

John P. Holmes, vice president of Celanese Corp. of America, has been assigned to direct the company's foreign operations. In addition to his position as vice president and a director of the parent company, Holmes has been appointed president of three subsidiaries, Celanese International Corp., Amcel Co., Inc., and Pan Amcel Co., Inc.

A native of Gainesville, Ga., Holmes graduated in 1926 from Georgia Institute of Technology, then worked there for one year as an instructor in textile chemistry and dyeing. He joined the Celanese organization in 1927.

Earl S. Neal has been named deputy representative on Middle East matters for Standard Oil Co. (New Jersey) in London, resigning his former directorship in Imperial Oil, Ltd., to accept the new post. Neal, a mining engineering graduate of the University of California, has served previously as chief geologist for Standard of

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9 out of 10 contractors say Lincoln Shield-Arc's can take it . . . and dish it out

- **SLOW SPEED ENGINES for long life**
- **Heavy-duty, rugged design**
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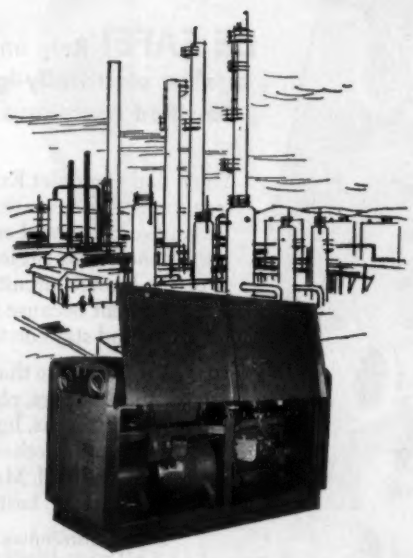
Gasoline engine driven models in 200, 300, 400, and 600 amp sizes.

Diesel engine driven models in 250, 300, and 400 amp sizes.

WRITE FOR SPECIFICATIONS on Lincoln Shield-Arc Welders. Bulletin SB-1356 on diesel driven welders and SB-1337 on gasoline driven models.



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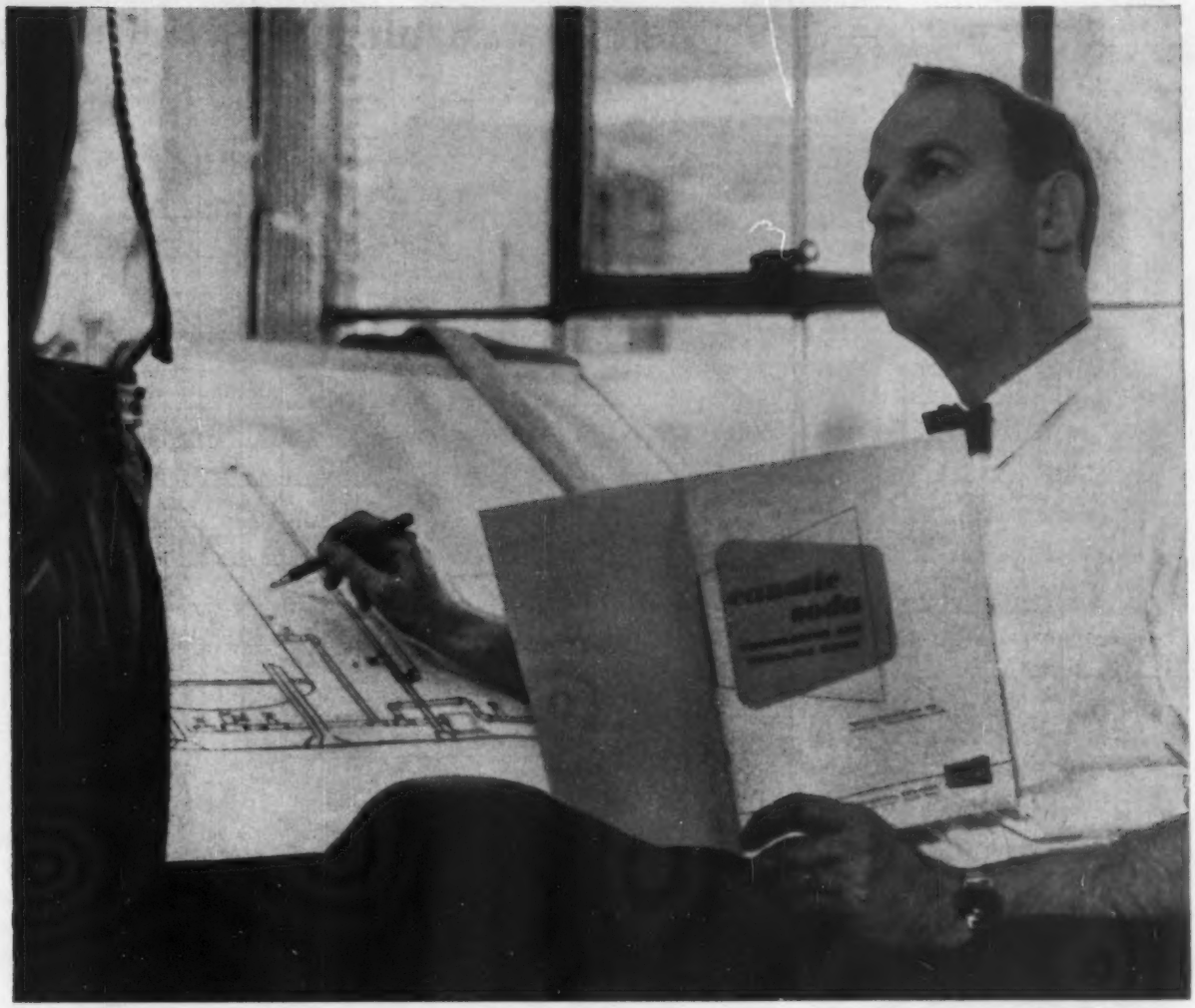

NEW HOOKER MANUAL helps you store and handle caustic soda safely

This new manual gives you 40 pages of information and advice on how to handle and store liquid caustic soda safely, efficiently, and with minimum risk of contamination.

Here are some of the contents:

- ✓ Large, detailed diagrams of equipment to use in unloading, diluting and storing.
- ✓ Commonly used methods for unloading a tank car of liquid caustic soda, for diluting to different strengths, and for storing.
- ✓ A section on safety precautions and first aid.
- ✓ A section on materials of construction.
- ✓ 18 charts, graphs and tables to help you predict and control the behavior of liquid caustic under a wide range of operating conditions. These cover such properties as dilution temperature, vapor pressure, viscosity, specific heat, etc.

For your copy of this new manual, write us today or use the coupon.

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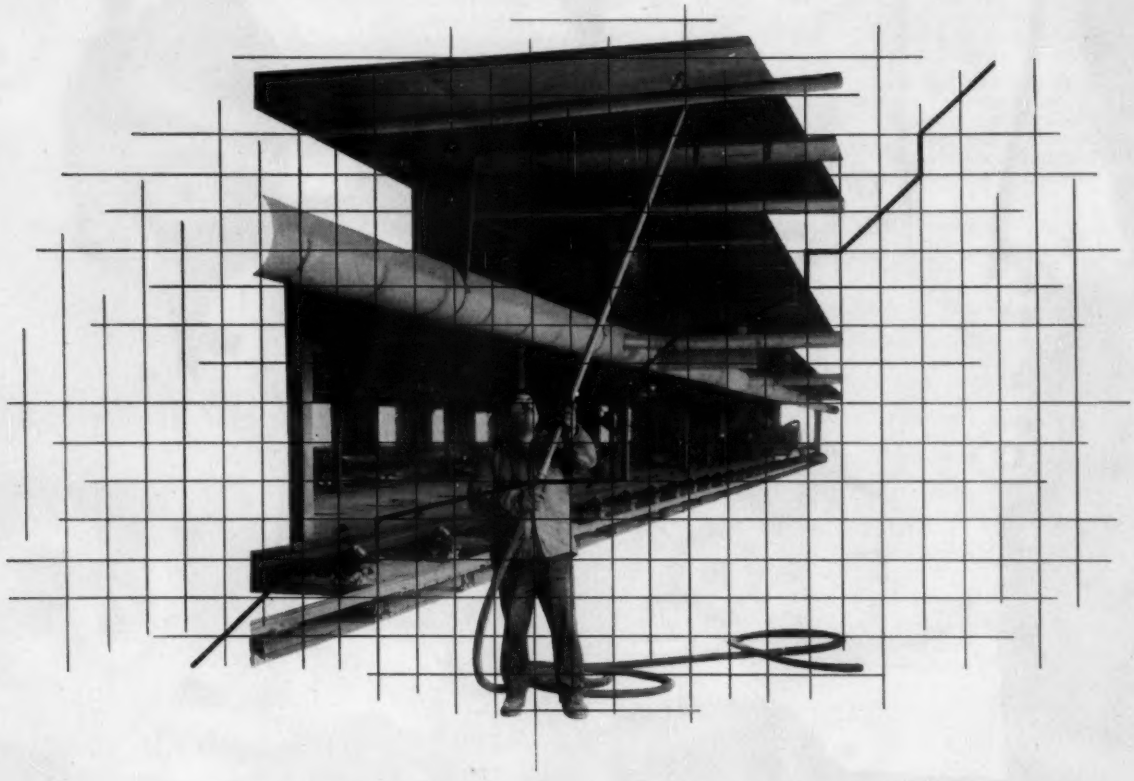
For more data on advertised products, use Readers' Service Cards, last page.

Hoffman engineered systems get **results:**



New York Port Authority finds that

HOFFMAN STATIONARY VACUUM CLEANING SYSTEM

removes dust...lowers cost...avoids danger, in its grain terminal!

And here's how: the installation of the specially designed Hoffman pneumatic system enables operators to get at all the grain dust: not merely on floors and lower walls, but high up, on remote ledges and along pipes. Special tools, like the goose-neck brush shown above are helping keep the terminal **thorough**-cleaned . . . to eliminate the hazard of dust explosion . . . to wipe out possible contamination points where insects could breed . . . to slice a big margin off labor costs.

If dust is hiding higher costs in **your** plant, mill or elevator, write today for a no-obligation estimate of the best way to get rid of it – for good. And get the full printed story on the New York Port Authority grain terminal, yours for free.

AIR APPLIANCE DIVISION **U.S.HOFFMAN MACHINERY CORPORATION** DEPT. PRR, 103 FOURTH AVENUE, NEW YORK 3, N.Y.

AIR APPLIANCE DIVISION Multistage Centrifugal Blowers and Exhausters. Pneumatic Conveying Equipment. Industrial Vacuum Cleaning—Portable and Stationary Systems. Continuous Metal Strip Driers. "Smoothflow" Fittings and Tubing. **INDUSTRIAL FILTRATION DIVISION** Machine Tool Coolant Clarifiers—Flotation, Mechanical, and Magnetic. Lubricating and Insulating Oil Conditioners, Filters, and Vaporizers. Solvent Recovery Systems—Vacuum Stills and Filters. **ORDNANCE EQUIPMENT DIVISION** Special Pneumatic Conveying Systems, High Efficiency Centrifugal Separators. Stationary and Portable Vacuum Cleaning Equipment. Process Equipment. Pneumatic Systems for Radioactive Materials.

YOU ARE CORDIALLY INVITED TO VISIT OUR BOOTH NO. 510 AT THE PLANT MAINTENANCE SHOW

Men in the Industry . . .

Venezuela (now Creole Petroleum Corporation) and later as head of the producing economics section of Jersey Standard.

de Decker

Nudenberg

Dr. H. K. J. de Decker, former research director of Holland's Rubber-Stitching research institute, and **Dr. Walter Nudenberg,** former member of the chemistry department of the University of Chicago, have joined the research staff of the Texas-U. S. Chemical Co. Dr. de Decker will head the polymer research section of the Research and Development department. Dr. Nudenberg heads the company's Exploratory Chemical Research section.

Robert Q. Sharpe, staff engineer of the industrial division of the lubricating department at Socony Mobil Oil Co., Inc., New York, has been appointed chief engineer of the department.

Sharpe, a mechanical engineer and a graduate of the University of Kansas, joined Socony Mobil in 1942 as a lubricating engineer. He is a native of Neodesha, Kans.

In his new assignment Sharpe succeeds **A. C. Stutson** who has been named assistant manager of publications and training for the department.

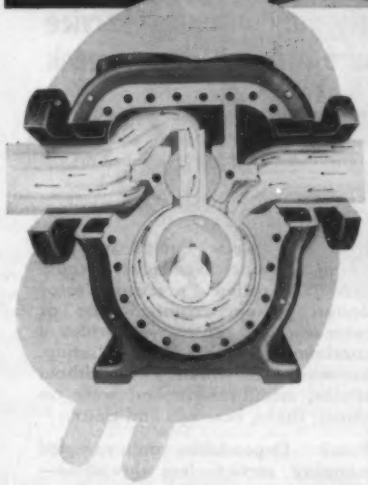
M. J. Rathbone, president of Standard Oil Co. (New Jersey), has been given the Stevens Institute of Technology award for notable industry achievement, in recognition of his work in "an industry so intimately involved with the industrial economy of our nation and in its military defense." The ceremony took place in New York. The Stevens award citation especially noted Rathbone's personal contributions to the technology of refining, in particular butyl rubber and other petrochemicals.

A. Carl Gladden, vice president and treasurer of the Texas Gas Corp., has been elected to membership on the board of directors. Elected vice presidents were **A. A. White,** secretary and general counsel and **Dr. Willard M. Dow,** director of research.

As newly-elected vice president, Dr. Dow now is in charge of manufacturing, engineering and research. **Earl Elliott** of the legal department has been elected assistant secretary. All other officers of Texas Gas Corp. were re-elected.

R. T. (Tom) Neville, formerly superintendent of the Winnie, Texas, plant of Texas Gas Corp., has been appointed general superintendent in charge of all plant operations. Neville became associated with Texas Gas in 1945 as plant foreman and was promoted to superintendent in 1954.

Charles C. Albritton, formerly superin-



The design of these Pumps, with oversize suction ports, makes them particularly suited to handle viscous liquids such as: lubricating and fuel oil, asphalt and other sluggish or gassy liquids. Positive displacement with high volumetric efficiency—frequently employed for calibrated output. Capacities 1 to 500 gpm, pressures up to 100 psi, (and some sizes up to 250 psi).

BUT • • •

Gambling on a Pump to Handle Bunker is Too Risky!

Take a KINNEY Pump. On the record, it will outlast any other pump in handling heavy viscous materials. While low depreciation is interesting . . . the BIG vitally important advantage in a KINNEY Pump is — FREEDOM FROM DOWN-TIME! It can cost you thousands to have a pump "conk" out at the wrong time . . . and chances are that's the time a "price" pump will fail. That's why, in viscous oil service, the odds are in your favor with a —

Kinney®

ROTARY PISTON PUMP

The Model SD KINNEY Pump consistently outperforms other pumps handling Bunker "C" oil, Tars and Asphalt at temperatures at least 20° cooler. Consider the time saved getting viscous materials up to pumping temperature. Consider the fuel saved over the course of a year. The savings are important, but the big, vital point is in the savings in down-time and the peace of mind you enjoy with a KINNEY Rotary Piston Pump on the job!

WRITE . . . for Bulletin L-51-A fully describing KINNEY Rotary Piston and the famous Heliquad Gear Pumps.

KINNEY MFG. DIVISION
THE NEW YORK AIR BRAKE COMPANY
3596C WASHINGTON STREET • BOSTON 30 • MASS.

Please send me Bulletin L-51-A containing full information on KINNEY Rotary Piston Pumps.

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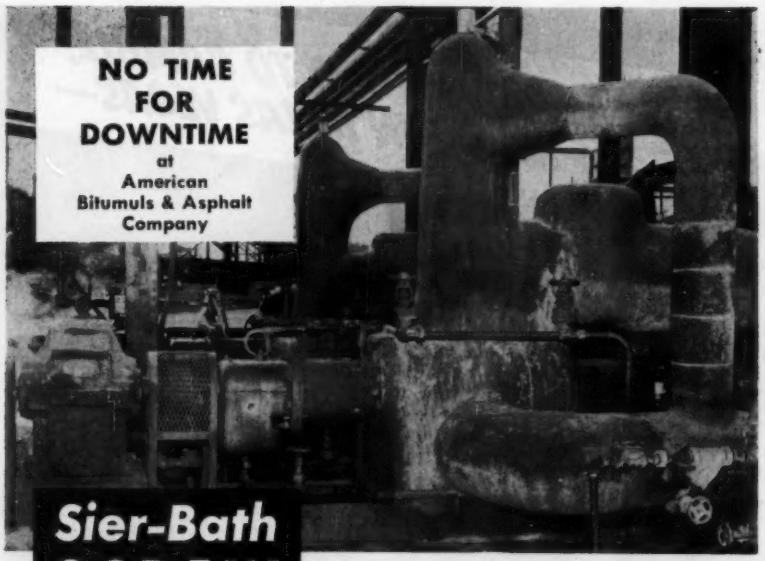
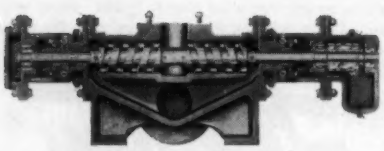


Sier-Bath SCREW PUMPS

— provide low-cost, reliable heavy-duty pumping service 24 hours a day, 7 days a week

• Shown above are two external bearing type Sier-Bath Screw Pumps at the Cincinnati refinery, charging low gravity crude oil to an asphalt unit. These steam-jacketed pumps have been handling crude oil with a viscosity of 10,000 SSU at 100°F. in 'round the clock operation for a period of 2½ years, with minimum routine maintenance.

Sier-Bath SCREW PUMPS



External Gear and Bearing Bracket Type for non-lubricating liquids and semi-liquids

Internal Gear and Bearing Type for lubricating liquids and semi-liquids

Sier-Bath Screw Pumps maintain high volumetric efficiency because "Dual-Controlled" precision rotor design prevents rotor-to-rotor or rotor-to-casing contact—provides a continuous flow without pulsation, hammering or vibration . . . without strains, misalignment and wear on rotors, shafts, bearings and gears.

Result: Dependable, uninterrupted pumping service—less downtime—less maintenance—easier servicing—longer pump life—lower overall pumping costs.

Capacities from 1 to 1,000 gpm.; viscosities from 32 SSU to 1,000,000 SSU; discharge to 1,000 psi. for viscous liquids, 200 psi. for water and light oils. Horizontal or vertical construction. Corrosion resistant alloys, special bodies, stuffing boxes and bearings for special needs. Call your Sier-Bath representative or write Sier-Bath Gear & Pump Co., Inc., 9261 Hudson Blvd., North Bergen, N. J

Sier-Bath ROTARY PUMPS

Screw Pumps Gearex® Pumps Hydrex® Pumps

50th Anniversary Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings Member A.G.M.A.

Men in the Industry . . .

tendent of operations at the Winnie plant, has been promoted to assistant general superintendent. He started with Texas Gas in 1945 as a shift foreman after discharge from the Air Force. During World War II, he served in North Africa and in Italy.

Malcolm T. McCants has opened his new consulting engineering offices in the Texas National Bank Building, Houston. His consulting services will be administered mainly to the petroleum and petrochemical industries.

McCants

McCants, before opening his Houston offices, was plant manager for the Great Northern Oil Co., St. Paul, Minn., where he supervised the design and directed the construction and operation of the 25,000 bpd refinery. For three years previous, he was general superintendent of the Great Southern Chemical Corp. at Corpus Christi.

–Deaths–

Samuel G. Keller, 65, a refinery manager of Socony Mobil Oil Company, Inc., until his retirement last year, died at his home in Gainesville, Texas. Keller had been with Socony Mobil 34 years and at his retirement was superintendent and manager of the Trenton, Mich., refinery.

Francis J. Cassidy, 61, well known Tulsa., oil man who was associated with The Texas Company's West Tulsa refinery, died January 27. He had been with Texaco for more than 30 years and was a professional baseball player before joining the company in the 1920's.

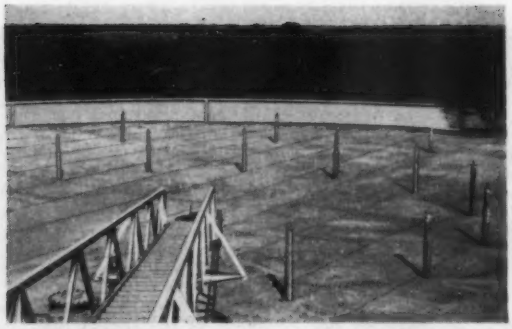
Carroll H. Tuttle, 65, reecntly retired southern division manager, Purchase and Stores department, Standard Oil Company of California, died in the Fresno Community Hospital.

Tuttle joined Standard of California in 1926 and retired last October 1. He was a resident of Los Angeles for 16 years.

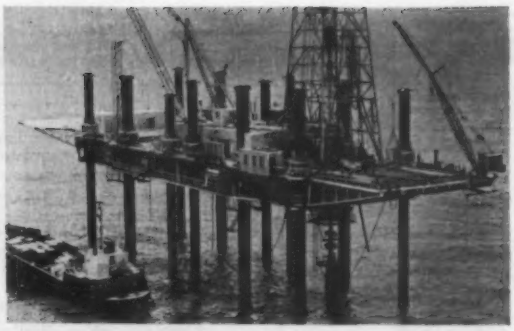
Charles W. Stewart, 69, Saratoga, former San Francisco executive, died while visiting friends in Providence, R. I. Stewart retired in 1952 as president of American Bitumuls and Asphalt Co., subsidiary of Standard Oil Company of California.

E. J. Griffin, 48, sales assistant to the vice president, West Coast marketing division of Shell Oil Co., died in a San Rafael, Calif. hospital. He had attended Montana State School of Mines and the University of Washington before joining Shell in 1930 in his home town, Butte, Mont.

Luke D. Barnett, Jr. died in a Houston hospital, February 8. A veteran salesman (20 years) with Aire Tool Manufacturing Co., he was district manager for the company at 2046 Banks, Houston.



on shore . . .



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your own painter can
"COLD GALVANIZE"
any steel surface with...

DIMETCOTE

* the 100% inorganic zinc coating

any **PLACE**

any **TIME**

any **WHERE**

Dimetcote is absolutely unique. It is not a paint, it contains no oils, resins or any other organic materials, yet it can be applied by spray or brush. When Dimetcote is applied to steel, a reaction takes place at the surface which produces chemical bonding as well as physical adhesion. It is almost impossible to find the interface between Dimetcote and the steel.

Dimetcote has many unusual characteristics. It shows no visible change after more than ten years exposure to the most severe weather conditions – sun, heat, fresh and salt water. It is insoluble in all solvents and petroleum products. It is highly abrasion resistant, but if abraded through to bare steel, the coating will cathodically inhibit corrosion.

Now tanks and structures can be given the same protection that galvanizing affords, *plus salt water resistance*. Existing structures need not be dismantled and new structures can be coated either before or after erection. *Only one coat* of Dimetcote over a sandblasted surface is required to protect such structures as:

Tank Exteriors • Cargo Tanks in Tankers • Dam Gates • Structural Steel • Christmas Trees • Buoys • Floating Roof Tanks • Offshore Rigs • Water Tanks • Barges • Ship Decks • Stacks

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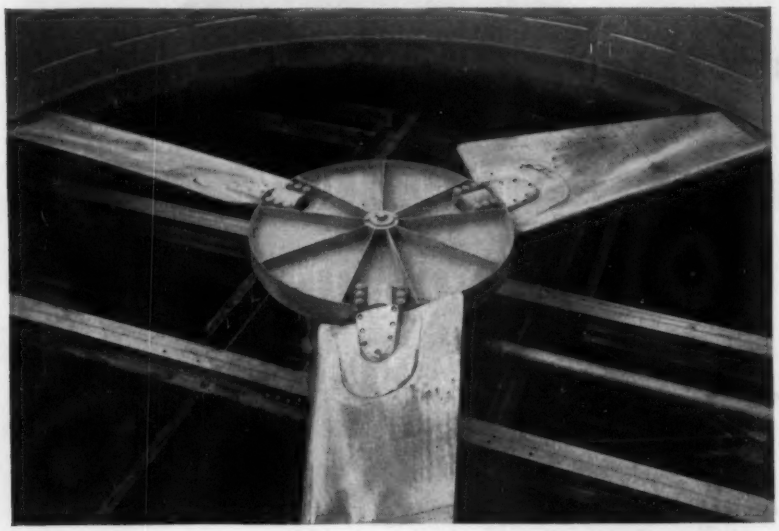
Reviewing New Books . . .

Manual of Consulting and Design Engineering Practices

The Michigan Engineering Society has published this booklet which contains "Outline of Engineering Services," "Definitions in Outline of Services," "Agreements and Scope of Services," "Bases for Engineering Fees," "Suggested Percentage Fee Rates," "Estimating Chart," Sample Agreement Forms, and "Canons of Ethics for Engineers." Its purpose is to inform public officials and private clients of the various kinds and types of consulting engineering services which are available to them and to give some idea of what they can expect to pay for these services. It contains the results of research for not only Michigan but for many other states in the nation.

(Executive Secretary, Michigan Engineering Society, P. O. Box 573, Kalamazoo, Mich., 20 pages, 50 cents for one copy, $4.00 for ten copies.)



HOW TO CUT COOLING TOWER MAINTENANCE COSTS

Hartzite plastic fan blades practically eliminate fan blade replacement problems in cooling towers and heat exchangers. They effectively resist corrosion, abrasion and vibration. Hartzite blades are constructed stronger to last longer. These tough, rugged blades are made of a phenolic-impregnated fabric-base material — solid construction . . . won't scale, won't peel . . . means low maintenance.

The hub section is dynamically balanced . . . solidly constructed of welded steel . . . with gussets for extra strength and increased safety.

Hartzite plastic fans are available in sizes from 10′ to 22′. Hubs are designed for 2, 3, 4 or 6 blade assemblies.

Find out more about how Hartzell helps you to cut cooling tower maintenance costs. Mail the coupon below for new bulletin A111B, "Cooling Tower and Heat Exchanger Fans".

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Division of Castle Hills Corp.
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Please send me a copy of Bulletin A-111B.

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Pump Selection and Application

To show the reader how to get more economy and efficiency from pump installations, in all the diverse fields where this equipment is used, is the objective of this newly-published book written by **Tyler C. Hicks**, a former PETROLEUM REFINER author.

Pumping problems peculiar to each industry are comprehensively covered, with step-by-step procedures for analyzing pumping problems, finding the most suitable commercial pump for the job, and applying this pump to the job conditions. Many illustrative examples are included.

Some of the special topics covered are pumping-system economic analyses, pump specifications, comprehensive analyses of the pumping requirements for a variety of industries, major discussions of pump head, liquid handled.

The book covers the entire field of industrial pumping—from tiny units handling just a trickle to giants pumping hundreds of thousands of gallons per minute. Many of the practical problems included are useful in reviewing for the stationary, mining and professional engineer's license examinations.

(McGraw-Hill Book Information Service, 327 W. 41st Street, New York 36, N. Y., 432 pages, $8.50.)

Engineering Uses of Rubber

Edited by Archibald T. McPherson and Alexander Klemin, this book offers a wholly new approach to the subject and paves the way for intelligent cooperation between engineer and manufacturer. Written by 18 well-known rubber technologists, it reveals why and how rubber is used rather than simply what it is used for. It also shows how this information can help solve special problems or develop new applications. Designed for the engineer and scientist outside the rubber industry, this book is also of value to the technologist within the industry for it contains unpublished data and information not readily available in the literature.

(Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y., 489 pages, $12.50. For sale by Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.)

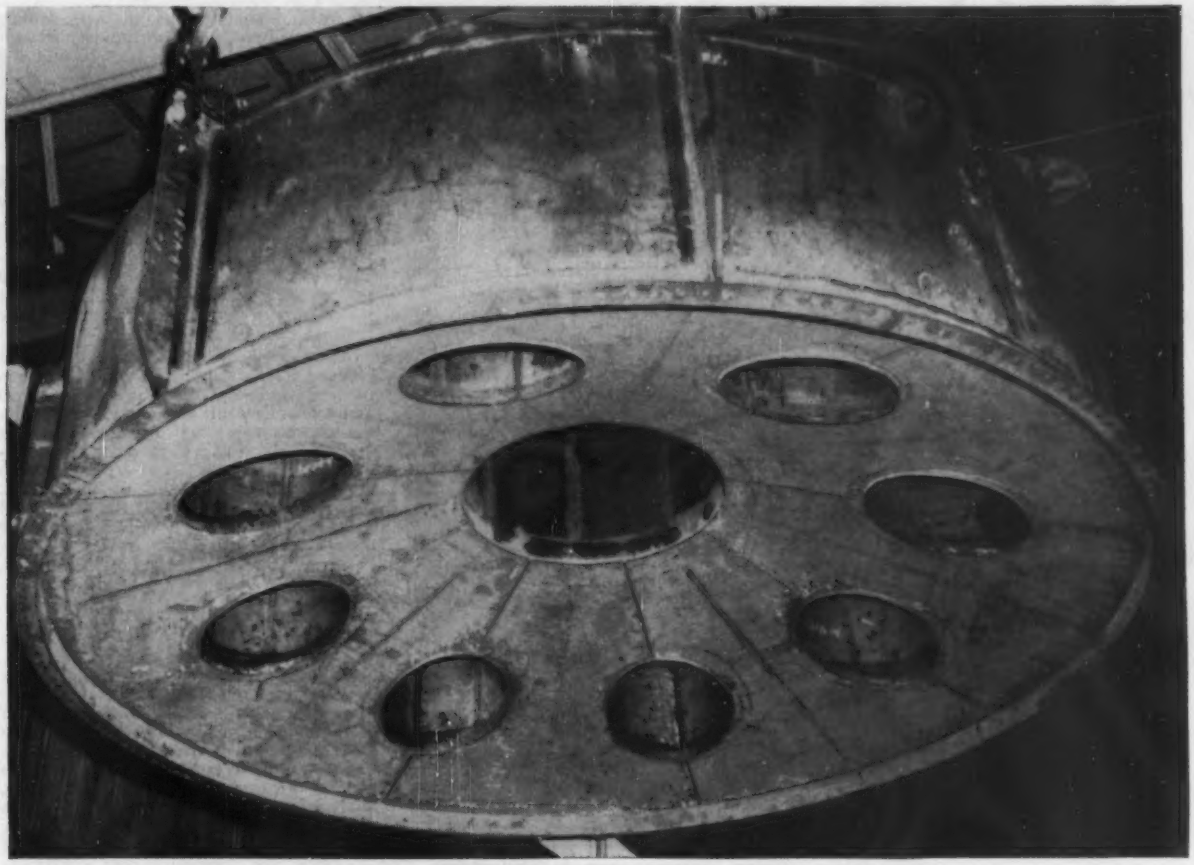
Waxes and Wax-Like Materials

This book reviews the science and technology pertaining to the manufacture of wax and wax products. It presents the results of research problems involving wax conducted in the Petroleum Refining Department at the Colorado School of Mines. Among the subjects covered are: composition and structure of waxes, physical properties, refining methods, and the effects of sonics upon crystallization and cracking waxes.

(Colorado School of Mines, Golden Colorado, 72 pages, $1.00.)

Documentation in Action

Edited by **Jesse H. Shera, Allen Kent**, and **James W. Perry**, this book records the proceedings of the 1956 Western Reserve Conference on the Practical Utilization of Recorded Knowledge. It presents a concerted up-to-date review of the science and art of effectively utilizing recorded information. The entire book brings together, for the first time, the many diverse documentation interests. Recent advances are summarized and evaluated with particular attention to systems, equipment for making information available as needed, use of recorded information in research



Hat size 240

Talk about ten gallon hats, here's a lid for a vaporizer that measures twenty feet in diameter. There were special problems of tailoring. There had to be stainless steel where the vapors flow to resist corrosion, and a carbon jacket to contain steam for heating.

The dome on top of this vaporizer acts as an inverted funnel. The holes you see in the dome are the outlets for the corrosive vapors. With an injection of steam, in the jacketed area of the dome, these vapors are re-heated to keep them in a gaseous state 'til they reach the next step in process.

More users and designers of process equipment are utilizing the "know-how" available at Chicago Steel Tank Company. This "know-how" assures you of a high-quality product at minimum cost whether your needs require fabrication from stainless steels, aluminum, nickel or any other alloy.

When you are anticipating the need for fabricated products, our sales engineers and engineering department are at your service.

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New Books . . .

and in decision-making, and education for librarianship. Every business organization, technical development and scientific research group, professional man and librarian will welcome this book as a valuable aid to new and improved information services.

(Reinhold Publishing Corp., 430 Park Ave., New York 22, New York, 471 pages, $10.00.)

Enterprise in Oil

This is the History of Shell Oil Co. in America. After explaining the organization of the Royal Dutch Shell group, author Kendall Beaton traces the growth of Shell Oil Co. from its start in 1912 as the West Coast marketing firm, American Gasoline Co. and an Oklahoma producing unit, Roxana Petroleum. A complete corporate history is provided, encompassing the charter and growth of Shell and its affiliates, Shell Chemical Corp., Shell Development Co., and Shell Pipe Line Corp. A special chapter describes the exciting booms at Signal Hill, Calif., with drilling rigs base-to-base. Illustrations include eight line drawings, seven maps, and 149 halftone illustrations.

(Appleton-Century-Crofts, Inc., 35 West 32nd St., New York, 816 pages, $7.50.)

Drilling rigs at Signal Hill, Calif., during big oil boom. Sometimes they were placed base-to-base.

Solvent Decarbonizing

Solvent Decarbonizing, a liquid-liquid extraction process, is the subject of a new "Kelloggram" just published by The M. W. Kellogg Co. The process was developed to supplement vacuum distillation and recover a substantially higher percentage of profitable catalytic feed from residues which would otherwise go to fuel or to thermal cracking.

After briefly describing the advantages of Solvent Decarbonizing, the Kelloggram proceeds to consider it from a technical and economic point of view beginning with the process operation in general. Charts are given showing typical yields and product properties from seven crudes. Solvent asphalt is described and its uses given. Solvent Decarbonizing is also compared with visbreaking and coking. It may be obtained by writing to: Advertising Department, The M. W. Kellogg Company, 711 Third Avenue, New York 17, N. Y.

Surface Treatment of Low Alloy Steels

A manual prepared as a guide to Air Force contractors in the selection of surface treatments for low alloy steels for corrosion and oxidation resistance has been released for industry use. The compilation of information and data includes general descriptions of coating techniques, analyses of temperature ranges to which each technique is applicable, cost and life limitations, possibilities of treatment of assemblies, and formability and weldability methods for materials treated before assembly.

Particular emphasis is placed on aluminum and nickel coatings, diffusion coatings (siliconizing, chromizing), miscellaneous metallic coatings, and certain heat resistant paints. Optimum application of treatments and techniques and their present and future use and distribution in industry are discussed.

(OTS, U. S. Department of Commerce, Washington 25, D. C., PB 121507, 261 pages, $5.00.)

Analysis of Crude Shale Oil 2. Some Brazilian and U.S.A. Oils

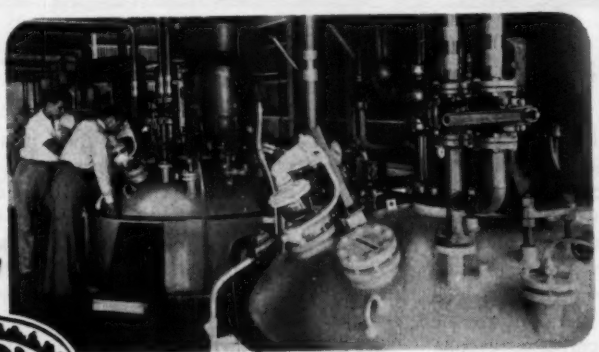
This report gives the results of analyzing three groups of crude shale oils by the Bureau of Mines. It includes data on the following: (1) Oils produced by standard Fischer assay determinations of oil shales from Brazil (Paraiba Valley) and the United States (Colorado); (2) oils produced from Brazilian shale by different retorting methods; and (3) oils from high temperature retorting of Colorado oil shale in the Entrained Solids retort.

This report is the second in a series presenting data obtained by analyzing crude shale oils from various sources. The series furnishes information on the general characteristics and composition of a wide variety of shale oils.

Some of this information was published by H. M. Thorne in "Retort Oil Shale for Chemicals, PETROLEUM REFINER, July, 1955, p. 155-160. However, this Bureau of Mines publication is a more thorough report of the crude analysis.

(Bureau of Mines, Publication Distribu-

Synthetic Rubber Industry Increases Output with



FRICK Refrigeration

Reactors Cooled With These Frick Coils Make Rubber Twice as Fast.

The big plants making synthetic latex at Baton Rouge, La., Naugatauk, Conn., Louisville, Ky., and Borger, Texas, have lately installed special Frick cooling systems for holding critical temperatures in reactors—in such remarkable fashion as to more than double their output! The advantages of "cold" rubber are thus made more available to everyone. Whatever the cooling problem in your business—air conditioning, ice making, quick freezing, or process work—you can rely on Frick refrigeration to solve it with dependability.

DEPENDABLE REFRIGERATION SINCE 1882

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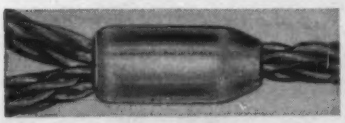
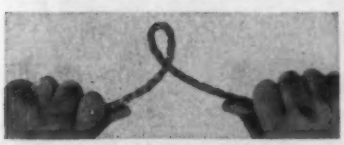
Tuffy® Sling Bulletin

Reporting the Outstanding Performance of Union Wire Rope's Machine-Braided Wire Fabric Slings.



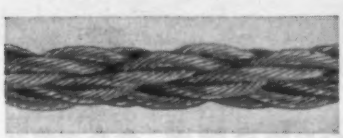
Streamlined Ferrules — Pressed On Over Tucked-In Splices — Give Tuffy Eyes Full Strength of Sling

It's on all Tuffy slings, and it doesn't cost you a penny extra. No sling ferrule like it anywhere! The ferrule is set on the eye splice under pressure so great that the eye splice has the full strength of the Famous Tuffy machine-braided wire fabric. It makes Tuffy slings stronger and safer. And still another advantage: because Tuffy slings are easier and safer to load, they're also faster to load. Yet Tuffy super-strong, super-flexible slings cost you no more than ordinary slings.



Hardly Ever Does a Kink Put a Tuffy on the Blink!

Try to kink a Tuffy sling — with all the force you can apply with two hands and the help of your feet. Chances are you'll need a vise. If you do succeed in putting a kink in that 9-part machine-braided wire fabric, you can straighten it out quickly and without materially damaging the fabric.



Tuffy Machine-Braided Wire Fabric — Successor to Wire Rope in Slings

Ordinary wire rope had the strength required for sling loads, but fell far short on the important qualities of flexibility, kink-resistance and ease of handling. Tuffy's patented 9-part machine-braided fabric combines super flexibility with extra toughness — costs no more than ordinary slings — and has uniformity of construction impossible to get in costly hand-braided slings.

Your Tuffy Distributor is Qualified to Help You Get More Service per Dollar from Slings and Hoist Lines

Send for FREE Tuffy Handbook of Slings and Fittings

For Canada, Safety Supply Co., Toronto

Distributors Fill Orders Fast on 16 Factory-Fitted Tuffys

Tuffy slings are factory-fitted, factory packaged and easy to order. They are delivered to you as a complete package — ready to go to work right now. Your distributor is ready to serve you, and he's backed up by his nearby Union Wire Rope depot.

No Complicated Specifications in Figuring and Ordering Your Tuffy Needs

Tuffys are tailored to special uses. Just select the Tuffy sling made for the type of load you're handling and (1) specify name — Tuffy; (2) specify type (U-1, U-2, etc.,); (3) specify diameter and length of fabric wanted. Special fittings are equally easy to order.

Tuffy Hoist Line Teams Up with Tuffy Slings

Tuffy Hoist Line is a special rope construction for hoisting on all types of over-head, stiff leg and mobile cranes, derricks and clamshells. Use it with Tuffy slings for a perfect working pair.

union Wire Rope corp.

2284 Manchester Avenue, Kansas City 26, Mo.

Specialists in high carbon wire, wire rope, braided wire fabric, stress relieved wire and strand

MY NAME _____ TITLE _____

COMPANY NAME _____

ADDRESS _____

2. CITY _____ ZONE _____ STATE _____

For more data on advertised products, use Readers' Service Cards, last page.

15,000 VOLT Anaconda Aerial Cable is field-assembled at Texas Division, Dow Chemical Company, Freeport, Texas.

This overhead cable reduces overhead costs!

Down time and repairs are costly—when storms knock out ordinary overhead lines. The answer is Anaconda Aerial Cable. This strong, sturdy cable gives peak protection against wind, snow, rain or sleet damage . . . offers *dependability and long-term economy!*

Aerial cable is easy to handle during installation—easy to splice, tap and terminate.

And, in plants where underground pipes or structures make installation of ducts or buried cable impossible or difficult, Anaconda Aerial Cable is ideal.

Neoprene jacket resists weather and abrasion. Special Anaconda Type AB butyl rubber high-voltage insulation gives extra protection against ozone, heat, moisture and fumes.

Ask the Man from Anaconda for full information on Anaconda's three types of Aerial Cable: 1) factory-assembled, 2) field-assembled, and 3) reverse-lay for easy tapping. Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

57337

SEE THE MAN FROM ANACONDA®

FOR AERIAL CABLE

New Books . . .

tion Section, 4800 Forbes Street, Pittsburgh 13, Pa., write for Report of Investigation 5286, 28 pages.)

Modern Mathematics for the Engineer

Written by experts well known for their theoretical competence and their practical experience in applied mathematics, this book presents a broad survey of the application of advance mathematics to today's rapidly expanding technology. This is the second of the contributed textbooks which grew out of the highly successful engineering extension lecture course at the University of California at Los Angeles. The first book in the series was *Modern Physics for the Engineer.*

In this book, the text is unique in its emphasis on the importance of stochastical analysis, the theory of games, operations analysis, and linear, nonlinear, and dynamic programming in modern engineering. The methods and applications of the new high-speed computation precedures are extensively covered.

(McGraw-Hill Book Co., Inc., 330 West 42nd Street, New York 36, N. Y., 490 pages, $7.50.)

Antiwear and Extreme Pressure Additives for Greases by **S. F. Calhoun** and **G. P. Murphy**, Rock Island Arsenal Laboratory, U. S. Army Ordnance Corps. Antiwear and extreme pressure properties of 27 additives to lithium soap-mineral oil greases were evaluated as part of research concerned with fortification of lubricants against increasingly severe conditions imposed by modern machinery. General trends indicated that additives containing phosphorous gave best antiwear properties, while those containing sulfur were superior against extreme pressure. It was found that two or more additives could be blended to attain improvements in both antiwear and pressure properties. Optimum antiwear and pressure qualities seemed to depend on factors not contained in the additive, such as oil viscosity, soap type and amount, and conditions of service.

(Order PB 111919 from OTS, U. S. Department of Commerce, Washington 25, D. C., 27 pages, 75 cents.)

ASTM Standards On Benzene, Toluene, Xylene, Solvent Naphtha (D-16) is a compact publication which has been compiled to collect all ASTM specifications and methods of tests pertaining to industrial aromatic hydrocarbons. In this convenient form it should be of great use to the industry. Committee D-16 on Industrial Aromatic Hydrocarbons and Related Materials sponsored this publication.

The compilation covers the entire range of specifications and methods of tests for industrial aromatic hydrocarbons including three specifications for benzene, three for naphtha, two for toluene and four for xylene. In addition, there are included in the volume nine methods of tests. Several appendices including a report of the activities of the D-16 Committee, a list of personnel of the committee and a proposed method of test may be found in this publication.

(American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa., 71 pages, $1.50).

AVAILABLE FROM STOCK...

CAMCO

Light Weight

FORGED CARBON STEEL

BACK-UP FLANGES

FOR LOW PRESSURE SERVICE

All surfaces protected with baked enamel finish.

Our line of FORGED CARBON STEEL BACK-UP FLANGES have found wide acceptance in stainless and other alloy piping installations of lightwall pipe. (Schedules 5 & 10.) We believe the economy effected by their use warrants your consideration.

For further details Ask for schedule **FCS-856**

FREE!

CAMCO Products, Inc., 445 State Street CE
North Haven, Conn.

☐ Please send Flange Dimensional Slide Rule.
☐ Send literature covering complete line.
☐ Furnish address of area distributor.

Name_____

Company_____

Address_____

City_____ State_____

CAMCO PRODUCTS, INC.

445 State Street
North Haven, Conn.

For more data on advertised products, use Readers' Service Cards, last page.

What Suppliers Are Doing . . .

Tobias

Arthur R. Tobias has been appointed to engineer in charge of the mechanical test room of The Garlock Packing Co. A native of Reading, Pa., Tobias is a graduate of Cornell University with a B.S. in mechanical engineering. He joined The Garlock Packing Co. in 1951, serving as a machine design engineer and later as supervisor in charge of the mechanical seal test room. Formerly an experimental technician with the Eclipse Machine division of Bendix in Elmira, New York, he is a member of the American Society for Metals.

Green

Wilson A. Green has been appointed to district manager of Eggelhof Engineers, Inc., Dallas, Texas. Prior to his appointment, Green was a sales engineer in the company's main office in Houston. He is a native of Houston, studied at Rice Institute from 1940 to 1943, commissioned as Ensign, U.S.N.R., in 1943 and served in Amphibious Force of 7th Fleet, Pacific Theatre for two years. He returned to Rice and graduated in 1948 with B.S. degree in mechanical engineering.

Phillips

Milton A. Phillips has been named Eastern United States representative for The Warner Lewis Co., a division of Fram Corp. Prior to his new assignment Phillips served as an assistant sales manager with the company in Tulsa. As eastern representative, he will supervise activities of the company representatives in Pennsylvania, New York and the Middle Atlantic and New England states.

Estes

Bay E. Estes, Jr., has been appointed director of staff administration for United States Steel Corp. In this newly created position Mr. Estes will have supervision of the advertising, commercial research, product development and market development divisions and in addition the administrative services of the commercial department. Estes joined U. S. Steel in 1939 as a member of the commercial research division in Pittsburgh. He was appointed director of commercial research, the position he held at the time of his present appointment, in 1948.

Nelson

Bert S. Nelson has been appointed director of engineering for the Products division of Hills-McCanna Co. Nelson, formerly chief engineer at Foote Bros. Gear and Machine Corp., will establish his headquarters at Carpentersville, Ill. A graduate of the Illinois Institute of Technology, Nelson is a member of the Society of Automotive Engineers and lives with his family in Hinsdale, Ill.

Carlson

Paul H. Carlson has been appointed advertising manager for The Babcock & Wilcox Co., Tubular Products division, Beaver Falls, Pa. Carlson has been associated with the advertising function since 1947. Previous to this he was supervisor of physical testing in the laboratory at the Beaver Falls plant. He is chairman of the Carbon Steel Product Development Committee of the Formed Steel Tube Institute and a member of the Publicity Sub-Committee of the committee of Stainless Steel Producers of The American Iron & Steel Institute. He holds membership in the Pittsburgh Chapter, National Industrial Advertisnig Association. A native of New Brighton, Pa., he was graduated from Oberlin College, Oberlin, Ohio, where he received an A.B. degree with a physics major.

Bach

Howard A. Bach has been appointed sales manager of Elliott Co.'s Lagonda division, Springfield, Ohio. Bach joined the company in 1951 as an apprentice engineer and after two years' training was assigned to Elliott's Detroit district office as a field engineer. In 1955, he was transferred to the Lagonda division as assistant sales manager. Bach graduated from Carnegie Institute of Technology in management enineering.

Holcombe

Dewey R. Holcombe has been named district sales manager of the New York City area for The Pfaudler Co. A native of Rochester, New York, Holcombe holds a B.S. degree in business administration from Syracuse University and has done graduate work in chemistry at Western Reserve University. Prior to joining Pfaudler in 1946 he served as a flight leader, 12th Air Force.

Kramer

Ralph E. Kramer has been appointed executive vice president in charge of general operations and sales for Hammond Iron Works. Kramer, vice president in charge of sales for Hammond during the past twelve years, is a member of the New York Nomads, a graduate of Carnegie School of Technology, and for many years prior to his association with Hammond was engaged in manufacturing and marketing heavy machinery and tools for the oil, mining and construction industries throughout the United States and many foreign countries.

Simpson

J. Robert Simpson, III, has been appointed sales manager for Conoflow Corp. He has been connected with the instrument and controls field for fifteen years, and has been associated with Conoflow in various capacities for the past ten years.

After completing his engineering studies at Lehigh University, Simpson spent several years with an instrument manufacturer and as an officer in the Navy Air Force. He joined Conoflow shortly after

NEW!

Blaw-Knox Grating and Tread Catalog

This brand-new, comprehensive catalog presents more useful application information than ever before. Complete descriptive information such as spacings, weights, panel widths and bearing bar surfaces are included for each type of grating.

In addition, a wealth of useful data such as tables of safe loads, fastening methods, and model specifications are included.

If grating application and installation is part of your responsibility, you should have a copy of this useful publication. Send for your copy today. No obligation, of course.

BLAW-KNOX COMPANY

Blaw-Knox Equipment Division

1104 Blaw-Knox Building • 300 Sixth Avenue • Pittsburgh 22, Pennsylvania

GRATING APPLICATIONS: floors • platforms • walkways • catwalks • stair treads • fan guards • shelving • and many other uses, both outdoors and indoors, for versatile steel grating

BLAW-KNOX EQUIPMENT DIVISION
1104 Blaw-Knox Building • 300 Sixth Avenue • Pittsburgh 22, Pennsylvania

Gentlemen: Please send me a copy of New Blaw-Knox Grating Catalog 2527.

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

For more data on advertised products, use Readers' Service Cards, last page.

this NO-COST TEST OFFER
has CONVINCED thousands
. . . send for YOUR FREE
"TEST CAN" of C-5 "hi-temp"
ANTI-SEIZE THREAD COMPOUND!

For chemical plant uses, on all studs and bolts exposed to temperatures up to 1800°F. such as on compressor head assemblies, hot pump studs, autoclaves, reactor flange studs, heaters, heat exchangers, "cat" crackers, stainless steel assembly.

Try C-5 and see why leading refineries, manufacturers and power producers have made it part of their regular preventative maintenance program.

fel-pro C5 "HIGH-TEMP"

- ✓ Ends Seizing and Galling even up to 1800°F.
- ✓ Reduces Wrench Torque
- ✓ Ends Stud Breakage
- ✓ Permits Repeated Re-use
- ✓ Speeds Assembly and Disassembly
- ✓ Protects Stainless Steel at all Temperatures

1614-C

ANTI-SEIZE THREAD COMPOUND

C-5's exclusive colloidal copper formula separates mating metal threads and surfaces with cushioning, protective copper plating. C-5 prevents galvanic action and eliminates pitting even when dissimilar metals join. On mating metal surfaces, C-5 saves gaskets and countless man hours.

WRITE TODAY . . . For Your FREE Test Sample Can of C-5.

FELT PRODUCTS MFG. CO.
1546 Carroll Ave., Chicago 7, Illinois

gilco
DRUM RECONDITIONING MACHINES

keep your drums making more trips

GILCO Traveler, Model 55-BHCL, simultaneously and automatically cleans the inside and outside of used steel drums. Incorporates chaining (scouring) and/or washing opportunity. Speed of operations depends on character of residue or internal rust to be removed. Model 55-BHCL is complete including hood and exhaust system, automatic loader and submerger and live roller conveyor.

There's a GILCO machine for every phase of steel drum reconditioning. For complete details and specifications on the equipment to solve your particular problem, write, DEPT. GT.

L. M. GILBERT COMPANY
1505 Race Street Philadelphia 2, Pa.
Cable: LMGILCO

How Metallizing saves money in refineries

cuts machine repair costs 80%—
cuts equipment "down-time"—
permits reduced spare parts stocks

Practically any worn machine part—repaired for only 15 or 20% of replacement cost—in minutes and hours, instead of days or weeks.

Pump shafts • Impeller journals • Motor shafts
Rotor blades • Packing areas • Pump plungers

The list of metallizing users in the Petroleum field reads like a Blue Book of the industry. Here are just a few:

Cities Service Refining Co.
Esso Standard Oil Co.
Gulf Oil Co.
Ohio Oil Co.
Phillips Petroleum Co.
Socony-Vacuum Oil Co.
Imperial Oil Co. (Canada)

METCO
Metallizing Engineering Co., Inc.
1157 Prospect Ave., Westbury, L. I., New York • cable: METCO
In Great Britain: Telephone: EDGEWOOD 4-1300
METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

WHEN SPECS CALL FOR...

STEEL PLATE

custom fabricated on the West Coast

Save on transportation costs, manufacturing time and put yourself in a more competitive position by contacting an experienced "on the spot" source when planning the procurement of process and plant equipment for the West Coast. Send prints for prompt quotation on your next job.

Request Brochure No. K-57

PS F SINCE 1900
PUGET SOUND FABRICATORS, INC.
Craftsmen in Metals
3670 E. Marginal Way • Seattle 4, Wash.
Craftsmen in steel plate and alloys up to 1"

Suppliers . . .

completing his tour of duty. For more than five years he was intimately involved in the development, application and marketing of many of the company's basic products. In 1951 he became a partner in the firm of J. R. Simpson & Co., Chicago representatives handling Conoflow equipment. Simpson remained in this capacity until his recent appointment as sales manager.

Penberthy Manufacturing Co. has named **J. C. Denis** director of research and development. Denis joined Penberthy in 1925. A graduate of McGill University, Montreal, Canada, and a registered professional engineer, Denis is one of the pioneer designers of the modern sump pump.

A. N. Lindeman assumes his new duties as chief engineer for Penberthy Manufacturing Co. A graduate of the engineering school of the University of Michigan and a registered professional engineer, Lindeman has been active in engineering and developing the ejector or jet pump and its applications in industry.

Hagan Chemicals & Controls, Inc., has appointed **Christopher P. Blakeley** chemical products engineer in the boiler chemical sales department. In his newly-created position, Blakeley will promote the sale of coagulant aids.

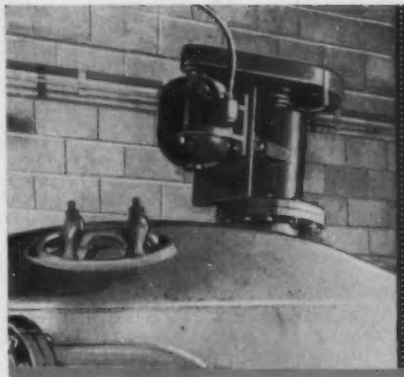
Blakeley joined Hagan from the Hyla Process Division of Salem-Brosius, Inc. Previously he had been employed for five and one-half years by the Dearborn Chemical Co., Chicago, Ill. He holds a B.S. degree in chemical engineering from the University of London, England.

C. H. Wheeler Manufacturing Co., Philadelphia, has appointed **Robert J. Benwell** manager of its Wheelerweld division, Ambler, Pa. Benwell succeeds **Frank G. Deker,** who retired as manager of the division after 40 years of active service.

Laclede-Christy Division, H. K. Porter Co., Inc., has appointed **H. H. Brandt** New York district sales representative. Brandt is a metallurgical engineering graduate of Lehigh University, Bethlehem, Pa., and is a member of the American Society for Metals, American Foundrymen's Society and American Institute of Mining and Metallurgical Engineers. Previously he was employed by National Carbon Co., and Bethlehem Steel Corp.

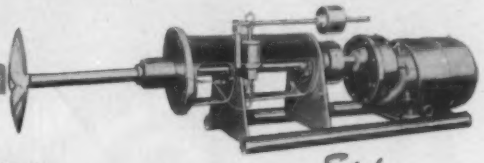
Selas Corp. of America, Dresher, Pa., has promoted **Howard Mehr** to supervisor, Industrial Publicity. In his new assignment, Mehr assumes responsibility for the company's industrial publicity activities, which includes originating and preparing technical articles and conducting editorial relations with the business and industrial trade press.

Roots-Connersville Blower Division, Dresser Industries, Inc, has promoted **Glenn H. Crocker** to manager, Factory Sales from chief application engineer, Centrifugal Equipment. He assumes responsibility for all sales application engineering functions at the headquarters in Connersville. A native of Kansas, he is a member of the American Society of Mechanical Engi-



You get ADVANCED Engineering - and better SELECTION -- with "International" MIXERS

Backed by Wide Application Experience



Each of these different types of Side Entering Mixers has its particular mechanical advantages which make it more efficient for specific purposes. There are many considerations in every application where a wide range of types and materials must be available.

With the complete "INTERNATIONAL" Line of Mixing Machinery to choose from, you can be sure of our unbiased recommendation and selection of the right type mixer for each specific job.

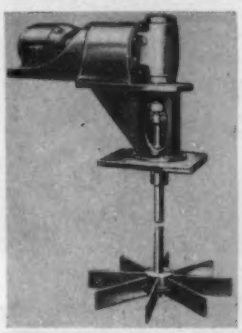
Special Metals used in Mixer construction are available,—iron, bronze, stainless steel, high nickel alloys, etc.—You pick the sealing arrangement, either standard packed or New Mechanical Seal. Your choice of Power drive—Gearmotor, V-Belt or Silent Chain.

MOTOR Selection—Any standard motor with NEMA frame—any current, insulation or enclosure.

GUARANTEED PERFORMANCE—25 Years of continuous building, testing, study and research experience goes into every "INTERNATIONAL" application—it assures you of getting exactly the right Mixer for top performance and economy.

Side Entering Mixers

1/2 to 30 H.P.



TOP ENTERING MIXERS

"INTERNATIONAL" Vertical Drive Heads are made in various types and sizes from 1 to 100 H.P. for Propeller and Turbine agitation,—slow speed or high speed—and for Open or Closed Tanks and vessels. Standard Stuffing Box or New Mechanical Seal.

PORTABLE MIXERS

Something new in flexibility—simplicity and efficiency—Interchangeable shafts and motors—changing from high to low speed or vice versa.

Gearmotor or Direct Drive—Sizes from 1/6 to 5 H.P. Electric and Air Drive types. Ask for Special Bulletin 74-A.

International Engineering, Inc.

DAYTON 1, OHIO

New York · 15 Park Row

Suppliers . . .

neers and of the Compressed Air and Gas Institute.

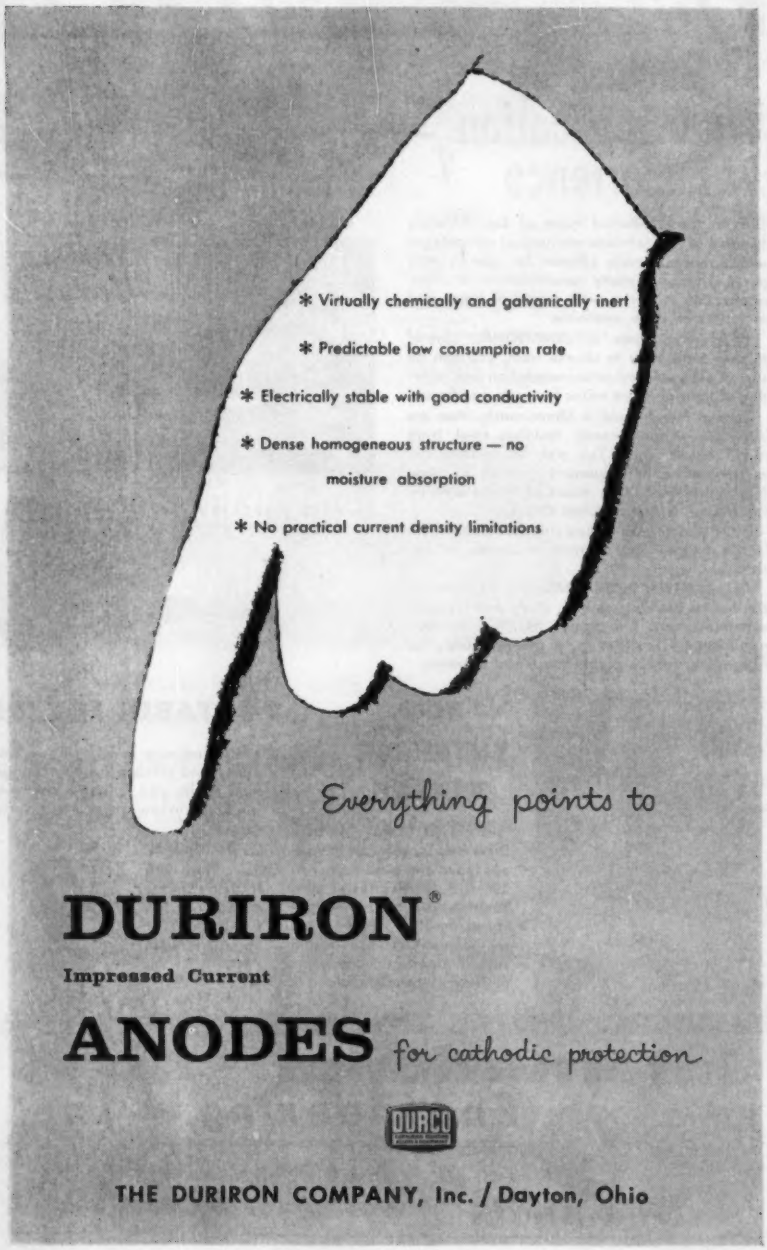
Also, **Joseph L. Hylton** has been promoted to the newly created post of manager, Market Research. He previously held the position of assistant to the sales manager and has been with the company since 1947. A native of Indiana, Hylton is a member of the American Marketing Association and the National Industrial Advertisers Association.

De Laval Steam Turbine Co. has appointed **M. M. Cameron** manager of its new office in Calgary, Alberta, Canada. Cameron was formerly with the De Laval Co., Ltd. of Ontario.

Frontier Chemical Co. has appointed **Frank Maxey** products manager for Agricultural Chemicals. His headquarters will be in Frontier's general offices in Wichita, Kans. **W. R. Pierre,** former sales coordinator, will replace Maxey as sales representative in the Dallas, Texas area.

Maxey has been associated with Frontier since January, 1956. He holds a B.S. degree in general science, chemistry and business. Before joining Frontier Chemical Maxey was Chemical Products manager for Sharples Chemicals, Inc., a division of the Pennsylvania Salt Manufacturing Co.

Before joining Frontier Chemical W. R. Pierre was with the W. C. Norris Co., Tulsa. He was also sales representative for General Chemical Division of Allied Chemical and Dye Corp. in St. Louis. Pierre is a graduate of Trinity College in Hartford, Connecticut.


* Virtually chemically and galvanically inert
* Predictable low consumption rate
* Electrically stable with good conductivity
* Dense homogeneous structure — no moisture absorption
* No practical current density limitations
Everything points to
DURIRON®
Impressed Current
ANODES for cathodic protection
DURCO
THE DURIRON COMPANY, Inc. / Dayton, Ohio

Farris Engineering Corp. has appointed **Wilfred McGregor** of Bogota, N. J., as divisional sales manager for the Farris Engineering Corp., Farris Flexible Valve Corp. and Farris Pickering Governor Co., Inc.

For the past eight years McGregor has been sales engineer for the three Farris companies. In his new capacity he will supervise all sales activity for the three product lines.

Wolverine Tube, Division of Calumet & Hecla, Inc., has appointed **William Bothwell** sales representative in Kentucky, southern Indiana and surrounding area. He replaces **Jack Sheehan,** who was recently promoted to manager of wholesaler sales.

Selas Corp. of America has formed a European subsidiary known as Selas Corp. of America, European Division S. A., with headquarters in Geneva, Switzerland, **Frederic O. Hess,** president, Selas Corporation of America, Dresher, Pa. announced. The new firm will serve industries throughout Western Europe.

Heading the Swiss Selas Corp. is **W. Jack Hofmann,** general manager, with **A. E. Baltus,** who has been general European representative for the past seven years, as sales manager.

Worthington Corp. has announced the establishment of the Industrial Centrifugal Compressor Sales department. This new Sales department will be under the Harrison division.

C. K. Hood, vice president and manager of sales for the Harrison division, has appointed **Everett C. Schmachtenberg,** formerly assistant to manager of engineering at Harrison, to head this new department.

Schmachtenberg has been with Worthington for over 19 years. He was born in Newark, N. J. and received his degree in engineering from the Newark College of Engineering. He is a licensed professional engineer in New Jersey and a member of the American Society of Mechanical Engineers and of the American Management Association.

Allied Chemical & Dye Corp., Solvay Process division has appointed **Arnold Hanchett** assistant director of development. Since 1952, Hanchett has been technical manager of Solvay's development department which handles all engineering and research work for the company's operations.

A graduate of Columbia University, Hanchett holds a degree in chemical engineering. He joined Solvay in 1920 as a plant chemist, transferred to the engineering department in 1930 as project engineer, and then was appointed a development engineer.

Hills-McCanna Co. has appointed **Bert S. Nelson** director of engineering for its products division. Nelson was formerly chief engineer at Foote Bros. Gear and Machine Corp. A graduate of the Illinois Institute of Technology, Nelson is a member of the Society of Automotive Engineers.

Ross Heat Exchanger Division of American-Standard, Buffalo, N. Y., has appointed **Paul W. Wilcox,** sales manager; **George G. Van Tuyl,** manager of power equipment sales, Eastern region; **Marvin F. Schobert,** product manager, standard exchangers; **Richard J. Riedl,** product manager, engineered, navy and atomic exchangers; **Lawrence M. Fletcher,** product manager, feedwater heaters; **William G.**

For more data on advertised products, use Readers' Service Cards, last page.

Small valve takes on big job at U.S. Steel

That's a 4" Aloyco Gate Valve of Aloyco 20 stainless steel guarding the outlet of one of the largest acid tanks ever built.

It's one of the new units erected as part of United States Steel's modernization of the Coke and Coal Chemical Division facilities at Gary, Indiana. Aloyco valves are widely used here in both the Otto Construction Corporation's ammonium sulfate saturators and in the solvent recovery units which were engineered by United Engineers & Constructors, Inc.

They're also widely used by other leading manufacturers in the chemical processing and petroleum industries. Perhaps Aloyco valves could save you money in handling corrosives. Want more information? Write Alloy Steel Products Company, Inc., 1301 West Elizabeth Ave., Linden, New Jersey.

6.27

to all NATURAL GASOLINE MEN

GREETINGS

from the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

We are looking forward to seeing you at the
THIRTY-SIXTH ANNUAL CONVENTION
of the NATURAL GASOLINE ASSOCIATION of AMERICA
APRIL 24-26, 1957
RICE HOTEL, HOUSTON, TEXAS

Members of the Natural Gasoline Supply Men's Association:

The Aber Company
Airetool Mfg. Co.
M. N. Aitken Company
Alco Products, Inc.
Alliger and Sears Co.
Allis-Chalmers Manufacturing Co.
Aluminum Company of America
American Air Filter Company, Inc.
American Meter Company, Inc.
Aquatrol, Inc.
Armco Drainage & Metal Products, Inc.
Arrow Industrial Manufacturing Co.

Barton Instrument Corp.
J. B. Beaird Company, Inc.
Bellco Industrial Engineering Company
The Belmas Co., Inc.
Berry Division—Oliver Iron & Steel Corp.
Bethlehem Supply Company
W. H. & L. D. Betz
The Bird-Archer Company
Black, Sivalls & Bryson, Inc.
Bowden Construction Co., Inc.
Braden Steel Corp.
U. J. Brammer & Sons
C F Braun & Co.
The Brown Fintube Co.
Brown and Root, Inc.
Burgess-Manning Co.
Butane-Propane News
Bryon Jackson Company

Cameron Iron Works, Inc.
John H. Carter Co.
Chicago Bridge and Iron Co.
Clark Bros. Co., Inc.
Climax Engine & Pump Mfg. Co.
Clowe & Cowan, Inc.
The Condit Company
Continental Products of Texas
Continental Supply Co.
C. Lee Cook Manufacturing Co.
The Cooper-Bessemer Corp.
S. C. Covington Co., Inc.
Joseph A. Coy Company, Inc.
Crane Packing Company
W. H. Curtin and Company

Dallas Tank Company, Inc.
Daniel Orifice Fitting Company
Davis Regulator Company
Davison Chemical Company
Dean Brothers Pumps, Inc.
Dearborn Chemical Co.
De Laval Steam Turbine Company
Delta Engineering Corporation
Dresser Engineering Co.
Dunham Tanks Div.—Anderson Dunham, Inc.

E. I. duPont deNemours and Co., Inc.

Allen Edwards, Inc.
Eggelhof Engineers
John W. Elder Company
Elliott Company
Elsey Corporation
Engine Life Products Corp.
Engineering Equipment Co.
Engineers and Fabricators, Inc.
Ethyl Corporation

Farnsworth & Chambers Co., Inc.
Farris Engineering Corp.
The Fish Engineering Corp.
The Fisher Governor Company
Flint Steel Corp.
Flow Measurement Co.
The Fluor Corporation, Ltd.
The Foxboro Company
France Packing Company

Gardner-Denver Co.
Garlock Packing Company
Gas Equipment Co., Inc.
Gasoline Plant Construction Corp.
General Electric Company
J. B. Gill Company, Inc.
Goulds Pumps, Inc.
Graver Tank & Manufacturing Co., Inc.
The Griscom-Russell Company
Grove Valve & Regulator Co.
Gulf Engineering Co., Inc.

D. W. Haering and Company, Inc.
Hammel-Dahl Co.
The Happy Company
Wyatt C. Hedrick Engineering Corp.
Hercules-Lupfer Engine Sales Co.
The Hilliard Corporation
T. F. Hudgins & Associates, Inc.
Hudson Engineering Corporation

Industrial Scientific, Inc.
Ingersoll-Rand Company
Insulation & Specialties, Inc.

Joy Manufacturing Co.

Kansas Paint & Color Co.
The M. W. Kellogg Company
The Koch Engineering Company
James S. Kone & Co.

Ladish Company
Max E. Landry, Inc.
Warner Lewis Company
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Manco Engineering Co.
Manning, Maxwell and Moore
Manzel
Market Dev. Div.—Phillips Petroleum Co.
The Marley Company, Inc.
Chas. Martin & Co.
Marsh Instrument & Valve Co.
The Marsh Co.
Massey Machine Div., Curtiss-Wright Corp.
C. A. Mathey Machine Works
Lynn McGuffy Co.
J. R. Meek Company
Messplay Machinery Co.
Mid-Continent Supply Company
Minneapolis-Honeywell Regulator Co.
Moorlane Company
Moran Furnace and Sheet Metal Co.

National Aluminate Corp.
National Tank Company
Natural Gas Odorizing Co., Inc.
Naylor Pipe Company
Nickles Machine Corp.
Nordstrom Valve Div., Rockwell Mfg. Co.
Wm. W. Nugent & Company, Inc.
Nutter Engineering Co.

The Ohio Injector Co.
The Oil Daily
The Oil and Gas Journal
Oil Well Supply Div.—U.S. Steel Corp.
Olin Mathieson Chemical Corp.
O. L. Olsen Co.
Orbit Valve Company

Pacific Pumps, Inc.
Paramount Supply Company
Peerless Manufacturing Company
Perry Equipment Corporation
Petro-Chem Development Co., Inc.
Petrocon Engineering Co., Inc.
The Petroleum Engineer
Petroleum Processing
Petroleum Refiner
Petroleum Week
Pierce Construction Co.
Pittsburgh Div., Rockwell Mfg. Co.
Plibrico Company
Podbielniak, Inc.
Power Machinery Company
Power Specialty Co.
J. F. Pritchard & Co.
Process Equipment Company
Puffer-Sweiven Co.

Edw. G. Ragatz Co.
Rawson & Co.
The Refinery Supply Company
Riddle and Hubbell
Robinson Orifice Fitting Co.
Rockwood Sprinkler Co.
Rogers Steel Corp.

E. W. Saybolt and Company
A. O. Smith Corporation
Smithco Engineering, Inc.
Snyder Company, Inc.
Southern Engine & Pump Co.
Southwest Industries, Inc.
N. C. Stearns Co.
Stearns-Roger Manufacturing Company
Stitt Ignition Co.
Stockham Valves & Fittings
Stone Instrument & Supply Co.
Superior Manufacturing Company

Taylor Forge and Pipe Works
Taylor Instrument Companies
Tellepsen Petro-Chem Constructors
The Tennant Company
Termomeccanica Italiana
Tube Turns Div.—National Cylinder Gas Co.
Tuloma Builders, Inc.
Tyler-Dawson Supply Co.

Union Steam Pump Sales Company
United Centrifugal Pumps
United Chemical Corp.
Universal Oil Products Co.

Vinson Supply Company
Vulcan Steel Tank Corp.

Walco Engineering and Construction Co.
Walworth Company
Well Equip. Div.—Chiksan Co.
Westcott and Greis, Inc.
Western Chemical & Supply Co.
Western Chemical Co. of K. C. Mo.
Western Supply Company
The Wickes Boiler Co.
Wilson Supply Co.
Woobank Machinery Company
World Petroleum
Worthington Corp.
Wright Chemical Corp.
Wyatt Metal and Boiler Works

John Zink Burner Company

Ritchie, product manager, surface condensers and ejectors.

As sales manager, Wilcox, formerly product manager of engineered exchangers and with Ross since 1944, will work closely with the regional managers of power equipment sales, as well as Ross Heat Exchanger's 11 district sales offices and 15 sales representatives.

Van Tuyl, transferred from the New York district office, became associated with Ross in 1944. Schobert, with Ross since 1941, has served in several capacities, recently as assistant manager of the Chicago district office.

Riedl was formerly assistant product manager of engineered equipment and has been with Ross since 1950.

Fletcher came to Ross in 1954 from Alco Products, Inc., where he was a sales engineer. Ritchie, a specialist in industrial fuel burning equipment with a Wisconsin firm, joined Ross last year.

Pittsburgh Corning Corp. has announced the appointment of **Harry E. Porter** as Southwestern manager of Foamglas industrial insulation sales. Porter will supervise the sale of Foamglas insulation in the industrial field in the southwestern states.

A graduate of the Georgia Institute of Technology with a degree in Architectural Design, Porter has been associated with Pittsburgh Corning since 1952 as a sales representative.

Linde Air Products Co., a division of Union Carbide and Carbon Corp., has named **H T. Ross** vice president—engineering according to **E. B. Suydam**, president of this division.

Ross joined Union Carbide in 1928 as a junior engineer at the laboratory of Linde Air Products Co. in Buffalo. He progressed through the Linde organization occupying various positions at different locations. He became manager of engineering for the company in 1955, which position he held at the time of his present appointment. Ross was born in Van Wert, Ohio. He received his B.S. degree from the University of Michigan in 1928.

Catlin Corp. of America has formed a new chemical division and has realigned thermosetting and thermoplastic sales on a divisional basis. Products now being produced for the petroleum and chemical industries will be among the first products to be marketed by the new division.

New sales divisions and their heads are **Edward W. Bastian**, sales vice president, Thermosetting division; **Frank E. Hadley**, newly created vice president, Thermoplastic division; **Paul A. Krentel**, Chemical division; **Viv Moss**, sales manager of special accounts, Thermosetting division; and **Jack Weiss**, vice president, sales manager of special accounts of the Thermoplastic division.

Three new assistant sales managers will be **Walter Betenbaugh**, Thermosetting division, Greensboro, N. C.; **David Stanley**, Thermosetting division, Chicago; and **Alfred D. Veale**, Thermoplastic division, Cleveland.

Delta Manufacturing Co. has appointed **Jack F. Merrill** as a sales engineer with the company's Oilfield Equipment division in Lafayette, La., it was announced by **Ross B. Baze**, vice president. Merrill formerly was associated with the Enardo Manufacturing Co. as a sales representative in Arkansas, Louisiana and Eastern Texas.

Chase Brass & Copper Co., a subsidiary of Kennecott Copper Corp., has promoted **Leland S. Hanson** from eastern regional sales manager to executive sales director. Also, **Charles A. Festge**, currently district manager for Chase at Milwaukee, Wis., will succeed Hanson; and **Edward J. Finn**, of the general sales department in Waterbury, will succeed Festge as district manager at Milwaukee.

Hanson, a native of Rochester, N. Y., has been with Chase since 1927. Since that time he has progressed through several important sales posts, including those of sales promotion manager, district manager at New York city for 11 years and, since 1947, eastern regional sales manager.

Festge, a native of Milwaukee, joined Chase as a clerk in its Milwaukee office in 1934. Within a few years he was promoted to outside salesman and in 1952 was advanced to district manager at Milwaukee.

Finn, a Waterbury, Conn., native, came to Chase in 1941. After four years in a variety of brass mill positions he was transferred to the New York City office, returning to the home office in Waterbury in 1948 where he has been associated with the general sales department ever since.

Suppliers . . .

Hooker Electrochemical Co. has promoted **William L. Gillespie** and **John T. Walms-**

CHEMICAL & MECHANICAL ENGINEERS

are offered opportunity to advance professionally in diversified growth company

Air Products offers you the opportunity to advance professionally and financially in the field of low temperature processing. The company is the leader in the engineering, design, manufacture, and construction of oxygen plants and systems for the separation of gases such as Oxygen, Nitrogen, Carbon Monoxide, Hydrogen, and other low boiling building blocks of the chemical industry. We must expand the entire organization to meet the increasing demands of the steel, metallurgical, and chemical industries.

The following opportunities are available at Air Products:

- PROCESS DESIGN: To apply thermo-dynamics, fluid flow, heat and mass transfer, distillation, absorption and adsorption to the commercial solution of complex gas separation problems.
- ESTIMATING AND ECONOMIC EVALUATION: To study and evaluate the economics of proposed systems and to estimate the cost of complete plants.
- PROJECT ENGINEERING: To coordinate the engineering, design, and construction of complete plants.
- MECHANICAL ENGINEERING: To design turbines, pumps, engines and special machinery to operate at extremely low temperatures. To coordinate the manufacture, procurement, installation and operation of large compressors, drivers and other machinery for the processing of gases and liquids.
- DESIGN ENGINEERING: Process equipment, pressure vessels, piping, structural, plant layout, electrical, instrumentation.
- CONSTRUCTION ENGINEERS: Supervision, start up, and operation.
- RESEARCH AND DEVELOPMENT: To explore new horizons in processing and equipment design. Analytical, experimental, design, pilot plants.
- SALES ENGINEERING: To negotiate the sale of complete low temperature systems for chemical, petroleum, metallurgical, industrial and government requirements.

Openings exist for all levels of experience. Training and rotation are provided. High salaries are combined with a profit sharing and bonus program. Professional development is encouraged—growth is continually creating new managerial positions.

This well diversified company offers an unusual challenge for engineers who seek a professional career in the atmosphere of a dynamic, growing company.

Write in confidence to learn more about our Company.
B. H. VanDyke, Air Products, Inc., P.O. Box 538, Allentown, Pa.

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For more data on advertised products, use Readers' Service Cards, last page.

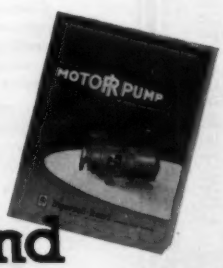
When you compare the Motorpump with any other pump . . . feature by feature . . . size by size . . . you'll quickly see why it is out in front for all liquid handling applications.

Installing it gives you *proof*. For one thing, you'll generally find you can use a *smaller* Motorpump to do the work assigned to pumps of larger horsepower. So costs are lower.

• Moreover, Motorpumps are so compact and efficiently designed that you save space and reduce power consumption. Installation is also simplified because they can be mounted in *any* position—on floor, wall or equipment—with no foundation needed!

Get to know the I-R Motorpump line—ranging in size from ¼ to 75 hp, 5 to 2800 gpm with heads to 650 feet.

Send for latest bulletin giving full data needed to choose a Motorpump.



Ingersoll-Rand

9-367 11 Broadway, New York 4, N. Y.

Suppliers . . .

ley to new posts in the sales department. The announcement was made by **John S. Coey**, eastern sales manager, at the company's headquarters sales office in Niagara Falls, N. Y.

Gillespie, formerly manager, Chicago district sales, now assumes the new title of manager, sales administration, and will move shortly from LaGrange, Ill., to Niagara Falls.

Walmsley, formerly Hooker sales representative for the Michigan and northern Indiana territory, will replace Gillespie as manager, Chicago district sales, operating from the company's sales office.

U. S. Gauge Division of American Machine and Metals, Inc., has announced additions to sales personnel at the factory and some of its factory branch offices, including a newly opened office at Dallas, Texas.

William H. Bolton is in charge of the new office at Dallas. Added to other offices were the following: **Donald Zook**, Houston; **L. R. Muha**, Chicago; **R. W. McWatters**, Cleveland; **C. F. David**, Los Angeles; and **J. H. Moore**, at the factory in Sellersville, Pa.

Beckman Industries, Inc., president **Dr. Arnold O. Beckman**, and **Louis D. Statham**, president of Statham Laboratories, Inc., Los Angeles, have jointly announced that agreement has been reached to merge the two firms, subject to the completion of legal details and the approval of shareholders.

The transaction will involve a stock exchange of up to 400,000 shares of Beckman for all of the Statham interests. Beckman currently has 1,287,227 shares outstanding.

Laclede-Christy Co. Division, H. K. Porter Co., Inc., has appointed **Robert J. Kiefer** sales representative in Chicago. Kiefer was formerly district works manager, fire brick production. Previously he was superintendent of the Laclede Works, St. Louis, Mo., and has been in production and sales at Laclede-Christy since 1941. Kiefer is a member of American Ceramic Society and the Refractories Institute.

Mexico Refractories Co. has made **Robert D. McWhorter** sales representative in Birmingham, Ala.

McWhorter has lived in Birmingham for the past 28 years. He is known in industry in that section having represented the Pittsburgh Plate Glass Co. before going into the refractory field.

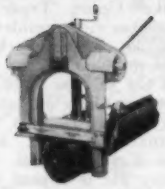
Solvay Process Division, Allied Chemical & Dye Corp., has appointed **Raymond B. Anthony** manager of the newly formed special chemicals section which combines the former special alkalies and ammonium and potassium products sections. **Fred P. Boehm**, who has been located at Solvay's central sales office, New York, moves to the company's Pittsburgh sales branch.

Under the new set-up **Solon D. Fisher** will serve as technical assistant to the manager of the newly formed section. **Joseph L. Hake** has also been named assistant to Anthony, while **George R. Barclay** becomes assistant to the manager of Solvay's Organic Chemicals section.

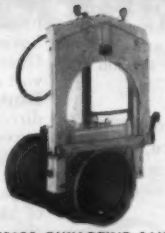
A graduate of Brown University, Anthony joined Solvay in 1928 as a sales-

For more data on advertised products, use Readers' Service Cards, last page.

WACHS *Portable*
POWER AND MANUAL PIPE CUTTERS
2" TO 72" CAPACITY



WACHS GUILLOTINE SAW
2" to 8" Capacity
Electric or Air Drive



"BIG" GUILLOTINE SAW
10" to 16" Capacity

WACHS CHICAGO

WACHS NATIONAL SAW
"The milling machine on wheels"
Cuts 10" to 72" Pipe

WACHS STRICKLER
RATCHET CUTTER
"Lathe Type Cuts"
5 sizes—2½" to 24" Capacity

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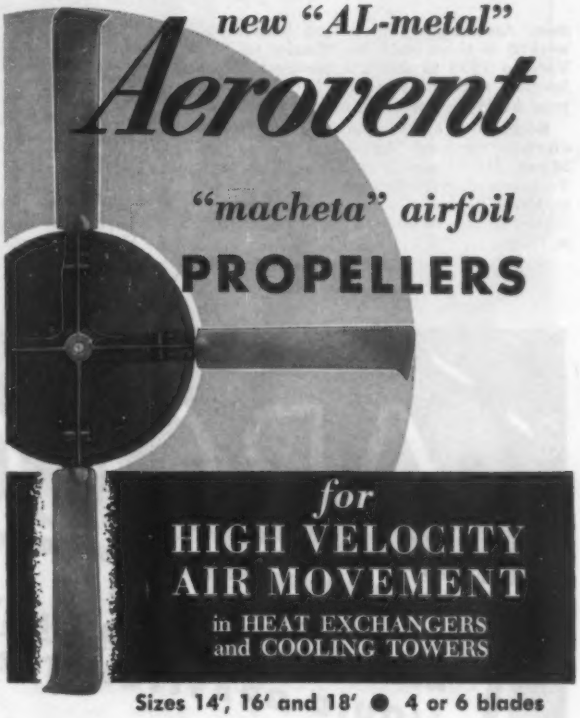

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HIGH VELOCITY AIR MOVEMENT
in HEAT EXCHANGERS and COOLING TOWERS

Sizes 14', 16' and 18' ● 4 or 6 blades

New Aerovent "AL-metal" Propellers for Cooling Towers, Heat Exchangers and special commercial and industrial applications, feature a new modification of the famous "Macheta" Airfoil Propeller – regarded for years as *industry's most efficient air-moving surface!*

Accurately-balanced, cast aluminum blades, designed to move *more* air with *lower* power consumption, are interchangeable with other blades in each assembly to speed and simplify installation and routine maintenance.

High-strength, cast steel alloy hubs, employing bolted construction, clamp keyed blade shanks securely to prevent loosening or turning; provide maximum resistance to vibration and operating stresses.

designed for DEPENDABLE *operation*

Endurance tests at *3 times* normal loading prove the ability of new Aerovent "AL-metal" Propellers to withstand punishment far in excess of operating requirements.

Other models for any type installation

Write today for free folder, engineering assistance and/or detailed performance data

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LARGE PROPELLER DIVISION
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Main Office and Factory
PIQUA, OHIO

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Suppliers . . .

man. Assigned to the Boston branch, he worked in there until his transfer to New York in 1953 as assistant manager of the Special Alkalies section. The following year Anthony was made manager.

Boehm received his B.S. degree in chemistry from the Texas College of Mines. He became a member of Solvay's Technical Service department at Syracuse in 1940. Boehm was assigned to sales activities at the company's New York office in 1953.

Hake was first employed by Solvay in 1941. After serving in the Navy during World War II, he returned to Solvay, assigned to the Special Alkalies section. Since 1949, he has been a salesman at the Detroit branch.

Barclay holds a B.S. degree in Science from the University of Toronto. With Solvay since 1950, he was technical service representative until moving to Detroit in 1951 as a salesman. Prior to his present appointment he had been assistant to the manager of the Special Alkalies section in New York.

ACF Industries, Inc., has elected **William T. Taylor** chairman of the board, **Charles J. Hardy, Jr.,** present chairman, announced. Taylor, who is now vice president and a director of Bankers Trust Co., has been a director of ACF since 1952. Hardy will continue as chairman of the executive committee and as a member of the board of directors.

Taylor will sever his connection as an officer of Bankers Trust, but will continue to serve on its board of directors. His 30-year banking career includes service as president of the Union Trust Co. of Springfield, Mass., as vice president of the Guaranty Trust Co. of New York, and as vice chairman of the Commercial National Bank and Trust Co. of New York. He is a director and member of the executive committee of both Adams Express Co. and American International Corp., and is a director of the First National Bank in Greenwich, Conn. He is a past president of the New York State Bankers Association.

Hardy joined ACF in 1944 as vice president and director. He was elected executive vice president in 1946, president in 1947 and chairman in August, 1954.

Panellit, Inc., has appointed **G. A. Walley** as chief engineer in charge of newly-opened Alhambra, Calif., manufacturing facilities. Prior to assuming his new post, Walley was senior project engineer for Panellit on the recently-completed instrumentation for the giant "Flying A" refinery of the Tidewater Oil Co. He is a graduate of Iowa State College, B.S. in chemical technology. Before joining Panellit in 1951, Walley was with Jos. E. Seagram and Son, Inc., in the process and plant instrument sections.

Norton Corp. has appointed **Osgood J. Whittemore, Jr.,** chief ceramic engineer of the company's Refractories division. In his new post, he will be responsible for manufacturing control and process engineering activities on all products made by the division.

Whittemore has been a member of Norton's Research and Development department since 1946. During this time he has worked on, or been responsible for, many of the new products which the company has introduced in the ceramic field.

He is a graduate of Iowa State College where he received a degree in ceramic engineering in 1940. The following year he received an M.S. degree in ceramic engineering at the University of Washington. Later, he was a Fellow at the Mellon Institute. In 1950, he was awarded the professional degree of ceramic engineer from Iowa State College. During World War II, he was a group leader on a phase of the Manhattan project being carried on at Massachusetts Institute of Technology.

Rockwell Manufacturing Co. has promoted **Herbert Parker,** sales engineer in the Atlanta, Ga., district office of the company's Meter and Valve division since June, 1950, to Atlanta district manager.

A native of Houston, Parker joined Rockwell in January, 1937, in the Houston district office. He became a sales engineer in the Houston area in 1940 and later served as a sales engineer attached to the Tulsa, Okla., district office.

Jefferson Chemical Company has opened a Cleveland sales office, it was announced by **D. L. Griswold,** general manager of the company's Marketing division.

R. J. Robinson, who recently returned to Jefferson from the U. S. Army Chemi-

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RECORDING CONTROLLING*
LIQUID GRAVITOMETER
CONTROLS BLENDING OF TWO OR MORE FINISHED PRODUCTS
. . . for Pipelines, Refineries, Chemical Plants, etc.
This new instrument serves to determine and record the specific gravity of liquids in the same manner as the standard Arcco-Anubis liquid gravitometer.
*In addition to these features, a controlling mechanism is provided, which may be pre-set to operate the pipe line, refinery, still and plant control valves to any specific gravity range required in blending two or more finished products.
Temperature corrected, this extremely accurate instrument is adaptable to high pressures and is available with internal parts of stainless steel for use with corrosive liquids. Send for bulletin No. 111-R3.
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Available for Early Delivery
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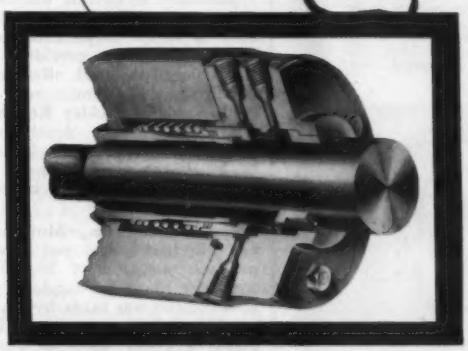
DO YOU HAVE SEALING PROBLEMS?



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Sealol-Flexibox Mechanical Shaft Seals have eliminated these problems. Flexibox features design simplicity and sturdiness . . . with sealing contact maintained by positive mechanical means . . . automatically compensating for dimensional changes due to temperature and pressure variations. Maintenance personnel like them because they minimize maintenance, provide drip-free operation, and can be easily assembled without adjustments and set screws. Flexibox seals adapt easily to existing or new pumping installations.

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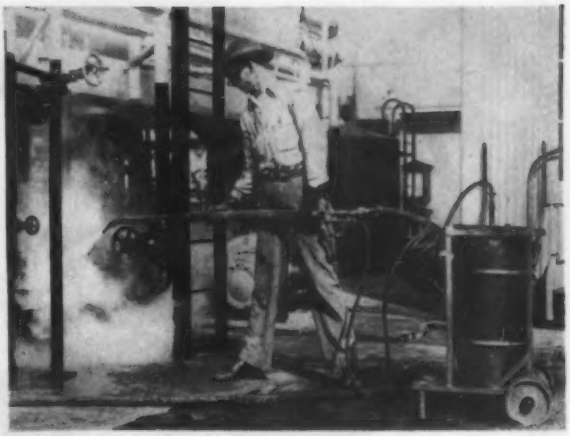
SEALOL

THE BALANCED PRESSURE SEAL



How a Man and a Gun Did 2 Weeks Work in a Day

A California refinery used to assign a whole crew of men, at regular intervals, to remove dirt, grease and muck from tanks, pumps and similar equipment. Hour after back-breaking hour they scraped, wire-brushed, wiped.

The Oakite Technical Service Representative nearby was consulted. He studied the problem, determined which one of Oakite's many specialized cleaners was best for the job, what concentration was most efficient, and suggested using an Oakite Steam-Detergent Gun – just one man and a gun.

As the plant superintendent said later, "About two weeks' work was completed in a single day." The man with the Oakite gun had more cleaning power than the whole crew!

Possibly at your refinery, too, there's a chance for big savings in maintenance cleaning. Call your local Oakite Technical Service Representative, or write to Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.

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VERTICAL COMBINATION GAS & OIL BURNER

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If the oil can be pumped, the "DA" can burn it.

No matter what calorific value gas is made available, this burner can handle it safely and quietly.

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Suppliers . . .

cal Center where he spent two years, has been named resident salesman and will report to **K. L. VanderVoort**, newly appointed Chicago district sales manager. Robinson is a chemical engineering graduate of Case Institute in Cleveland.

Baker-Raulang Co. has named **Robert A. Laws**, formerly assistant chief engineer, as manager of sales engineering, according to **G. B. Davis**, director of sales. Laws came to Baker-Raulang after 15 years of active duty with the Marine Corps.

A 1946 graduate of the United States Naval Academy, Laws did post-graduate work in engineering at the University of California in 1952 and 1953. He is a member of the Cleveland Engineering Society.

Green Fire Brick Co. president **W. S. Lowe**, and **R. H. Remmey**, president of the Richard C. Remmey Son Co., Philadelphia, have announced the acquisition of the Remmey Co. by the Green Co.

Remmey is now a wholly owned subsidiary of A. P. Green and will operate as a separate corporation with **John G. Remmey** as vice president and general manager. Robert H. Remmey, who was president, will remain with the firm as consultant. **G. Bickley Remmey** will be in charge of research, development, and engineering, and **Francis G. Remmey** will be in charge of operations. The name of the firm will remain unchanged.

Crane Packing Co., Morton Grove, Ill., has purchased and put into almost immediate operation a 30,000 square foot one-story plant in Vandalia, Ill. This announcement was made by **Karl V. Rholen**, president of the company. The Vandalia plant is being used to augment Crane Packing Co.'s home plant manufacturing facilities.

Union Carbide and Carbon Corp. has appointed **D. S. Alcorn** assistant manager and **T. J. Hall** product manager of Fine Chemicals, according to an announcement by **W. A. Woodcock**, manager of the Fine Chemicals department of Carbide and Carbon Chemicals Co.

Alcorn has been associated with the company since 1943, when he was graduated from the University of Pennsylvania with a B.S. in chemical engineering. Except for a leave of absence from 1944 to 1946, when he was in the Navy, he has been associated continuously with marketing and product development activities. As a technical representative he helped develop many of the company's chemicals

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for textile applications. In his new position as assistant manager he will add the development of acrolein and peracetic acid markets to his responsibilities in these fields.

Dr. Hall joined Carbide and Carbon in 1952 after receiving his Ph.D. degree at the University of Rochester. His undergraduate work was done at Carnegie Institute of Technology. He was a Fellow of Mellon Institute of Industrial Research at Pittsburgh. His responsibilities at Carbide have included the development of markets for chemical intermediates.

Stauffer Chemical Co. has appointed **Charles W. Mitchell** to vice president of the company and general manager of the Nyotex Chemicals division. He will make his headquarters in Houston.

Mitchell joined Consolidated Chemical Industries, now a division of Stauffer, in 1929 and during the ensuing 24-year period assumed the positions of traffic manager, sales manager, general manager, and vice president and general manager of Consolidated's southern division plants. When Nyotex Chemicals, Inc., was formed in 1942, Mitchell became an officer and director. In 1935 he was named executive vice president and general manager of Nyotex.

The Republic Supply Company of California announces an addition to sales personnel in the firm's Refinery Sales department, according to **Glenn E. Pitts**, vice president manager oilfield sales. Salesman **Thomas W. Hoyer** has been transferred to this department.

Thomas W. Hoyer came to The Republic Supply Company as a trainee in 1951. In 1954 he was promoted to store supervisor in charge of the company's Newhall Ranch store. The following year, he was promoted to salesman and was stationed at the Ventura Branch, whence he moved to the Long Beach store in 1956, before the present change to main headquarters, Los Angeles.

J. F. Pritchard and Co., Kansas City, Mo., has announced the promotion of **E. E. Frye** to vice president and manager of the Petroleum division.

Frye, a graduate of Washburn University and the Massachusetts Institute of Technology, joined the Pritchard organization as manager of the Gasoline Plant section of the Petroleum division in 1947.

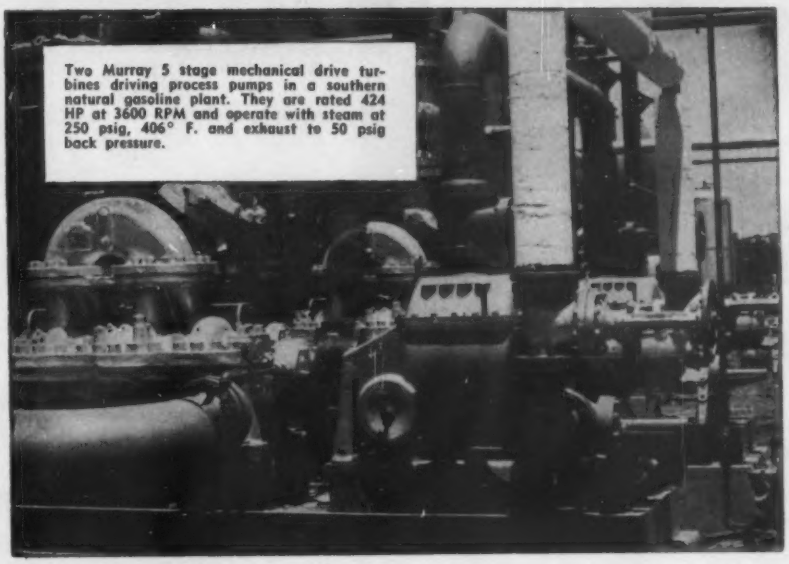
Air Reduction Pacific Co., a division of Air Reduction Co., Inc., will launch construction of a multi-million dollar air separation and liquefaction plant at Bassett, Calif.

The new plant, which will be of completely modern design, will produce daily 55 tons of high purity liquid oxygen, 15 tons of liquid nitrogen, and three and one-half tons of liquid argon. The cost of the plant, including related delivery facilities, will be in excess of $7.5 million.

Scheduled for completion late in the year, the new plant will serve primarily the aircraft, steel, metal fabricating, chemical and food processing industries in the California, New Mexico and Arizona areas.

Air Reduction Pacific Co., headed by H. P. Etter, president, who will attend

Murray Turbines



Two Murray 5 stage mechanical drive turbines driving process pumps in a southern natural gasoline plant. They are rated 424 HP at 3600 RPM and operate with steam at 250 psig, 406° F. and exhaust to 50 psig back pressure.

● MURRAY TURBINES for mechanical drive can be furnished for various combinations of the following conditions:

Horsepower up to 15,000
Speeds up to 11,000 RPM
Steam up to 600 psig, 750° F.
Back pressures up to 300 psig, or condensing

● MURRAY mechanical drive turbines are built in various combinations as follows:

Single stage turbines
Multi stage turbines
Mechanical fly ball type governors
Oil pump direct acting oil governors
Oil pump oil relay governors
Fly ball oil relay governors
Single governor valve with or without hand valves
Multiple automatic governor controlled inlet valves

MURRAY IRON WORKS COMPANY
BURLINGTON, IOWA

Builders of Steam Power Equipment for Three Quarters of a Century

For more data on advertised products, use Readers' Service Cards, last page.

STOPPLE APPLICATION
HOT TAPPING
PIGGING
BUSHINGS & INSULATORS

Agent for T. D. Williamson, Inc.

MARKER VENTS
AERIAL MARKERS
WELL MARKERS
SAFETY SIGNS

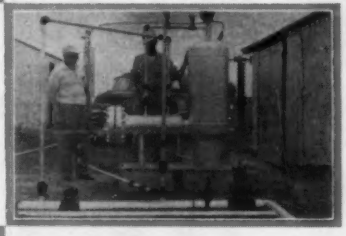
Sole Distributors for L & M Co.

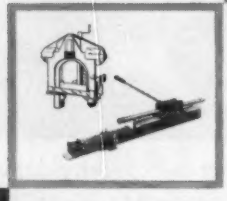
ASPHALT OUTERWRAP
ASPHALT COATING
ROCK SHIELD

Agent for Gulf States Asphalt Co.

H & H GAS ODORIZERS
Built to your specifications

Manufactured by Tod Pazdral





GUILLOTINE SAWS
NATIONAL SAWS

Agent for E. H. Wachs Co.

MERCURY HYDRAULIC
PIPE PUSHERS

Tell 'Em
We'll Be There!

You can depend on Topaz sales engineers to be on the job--on time--working in cooperation with your engineering department. Topaz service includes furnishing all equipment on a lease, contract or purchase basis. Call Topaz day or night . . . we'll be there!

TOD PAZDRAL
PIPELINE SPECIALTIES
2525 South Boulevard • Houston 6, Texas
Day Phone JA 2-1403 • Night Phone MA 3-5680

ToPaz

Suppliers . . .

ground-breaking ceremonies, is Air Reduction's West Coast industrial gas and welding products division with headquarters in San Francisco. The Los Angeles district, in which the new plant is to be located, is under the supervision of **E. W. MacCorkle, Jr.**, Air Reduction Pacific Co. president.

Southwest Fabricating & Welding Co., Houston, a subsidiary of Walworth Company, has elected **Ardon B. Judd** president. **Fred W. Belz**, president of the parent company, becomes chairman of the board of Southwest.

Judd joined Southwest in 1951 and became executive vice president and treasurer on January 1, 1956, when Walworth acquired the company. He will continue to serve as treasurer.

A native of Nebraska, Judd has made his home in Texas since he was three. After attending Denison University and the University of Texas Law School he was with the legal department of Cia. Transcontinental de Petrolcos, S. A., in Tampico, Mexico, until 1922 when he joined the Republic Supply Co., a subsidiary of Republic Steel.

North American Philips Co., Inc., has appointed **Philip I. Wolf** field sales manager, Wolf will supervise sales operations for the regional offices of the division in Chicago, Houston, Philadelphia and Mount Vernon. He will also coordinate sales efforts of franchised dealers.

Wolf joined North American Philips in 1953 and until his new appointment served as resident sales and application engineer for Norelco in the western part of the United States with his offices in San Francisco. He is a member of several technical societies.

National Can Corp. has appointed **George F. Henschel** vice president and general manager of sales, it was announced by **Robert S. Solinsky**, president.

Henschel joins National Can Corp. from American Can where he has held a variety of executive sales positions since 1930. These posts included sales manager for non-food containers, sales manager for the Buffalo and Philadelphia districts, sales manager for the Atlantic division, general sales manager of the beverage division, and general manager of sales.

Kaye-Tex Manufacturing Corp., Yardville, N. J., has announced the appointment of **Martin Rosen** to the post of technical director of Kaye-Tex Manufacturing Corp. Rosen joined the company in 1952 as a chemist. He also held the position of chief chemist and has been a member of the technical sales staff.

Rosen will also be responsible for the direction of technical activities of the company's wholly-owned subsidiary, Kaykor Industries, Inc.

Rochester Manufacturing Co., with plants and head office in Rochester, N. Y., has formed an engineering-manufacturing subsidiary in Pasadena, Calif. **Allen H. Ottman**, RMC president, announced that the new wholly owned subsidiary will be known as the Rochester Manufacturing Co. of California.

Two Pasadena residents will be operating heads at RMC of California. **Haylett B. Shaw** will hold the position of general

For more data on advertised products, use Readers' Service Cards, last page.

THE STONE & WEBSTER RIPPLE TRAY*

A Notable Development for the Process Industries

BELOW:
Ease of installation is a plus factor for Stone & Webster Ripple Trays.

The unique RIPPLE TRAY, developed and designed by Stone & Webster Engineering Corporation, brings new concepts of economy and efficiency to fractionation.

The high capacity and simplicity of construction of RIPPLE TRAYS have effected major savings in first cost over conventional bubble cap trays. Full tower cross section is utilized for active contact of liquid and vapor. No downcomers are required.

Because of their unusual self-cleaning feature, downtime for maintenance of RIPPLE TRAY-equipped fractionation units is reduced to a minimum.

Efficiency maintained over a wide operating range makes RIPPLE TRAYS adaptable to practically every type of service.

Commercial performance has established their acceptance in the process industries.

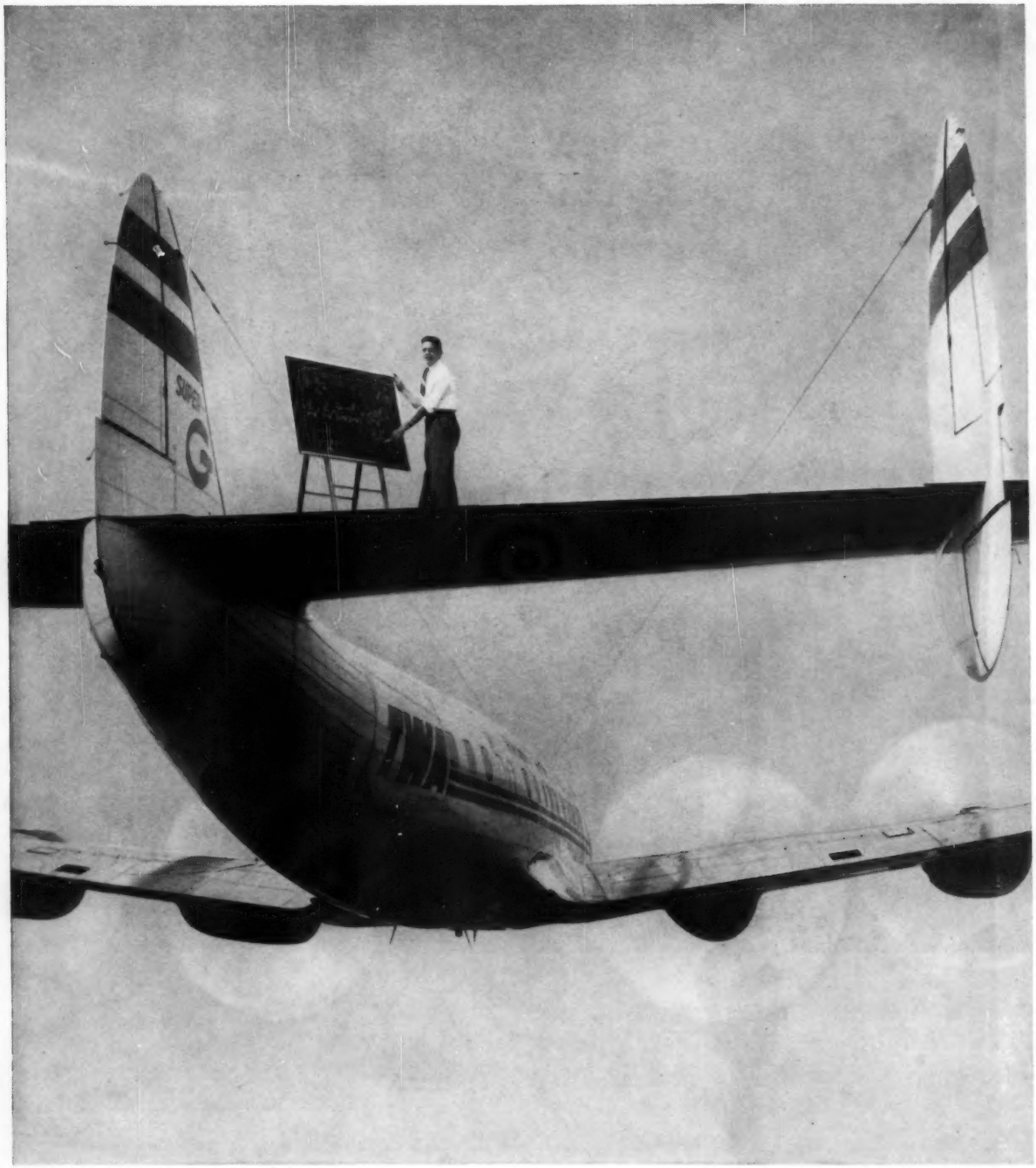
Write or call us for our illustrated booklet, "The Stone & Webster Ripple Tray".

**Trade-Mark*

STONE & WEBSTER ENGINEERING CORPORATION

AFFILIATED WITH E. B. BADGER & SONS LIMITED (LONDON)

New York Boston Chicago Pittsburgh Houston Los Angeles San Francisco Seattle Toronto



Oilmen should be up in the air! An oil company physicist and his slate of equations may seem out of place in the sky. But airmen couldn't get off the ground without oilmen. Oil helped fly 50 million passengers on U. S. air lines last year. And oil company researchers are developing jet and rocket fuels that will shrink tomorrow's world even more. Remember these things when you hear misinformed people speak against your industry. Speak up—tell how you help give America wings! **SHELL OIL COMPANY**

Suppliers . . .

manager. He previously had been president and general manager of Graphik Circuits, Inc. of Pasadena, producers of printed circuits.

James E. Lindsay, inventor of the Lindsay high pressure gauge, will be manager of engineering. He formerly was a scientist in research at California Institute of Technology.

Wolverine Tube, Division of Calumet & Hecla, Inc., has appointed **John V. Betz** sales representative in the New York area. He will be concentrating his selling activities primarily on wholesaler customers of Wolverine.

Formerly with Gar Supply Co. of Long Island, Betz will headquarter in Wolverine's New York office.

Jefferson Chemical Co. has opened a Cleveland sales office. **R. J. Robinson,** recently returned to Jefferson from the U. S. Army Chemical Center where he spent two years, has been named resident salesman. Robinson is a chemical engineering graduate of Case Institute in Cleveland.

Corning Glass Works, vice president and director of purchases of **Russell Brittingham,** has been chosen the next president of Pittsburgh Corning Corp. to succeed **H. B. Higgins.** Higgins is chairman of the board of Pittsburgh Plate Glass Co.

Before joining the Corning organization in 1944, Brittingham had been engaged in sales work in the automotive specialty and publishing fields. His first assignment with Corning was as administrative assistant to the director of research. He served as general manager of the Technical Products division from 1946 to 1956, including management of the Consumer Products division from 1948 to 1951. In 1954 he was elected vice president and for the past year has served as director of purchases.

Tube Turns, Louisville, Ky., has added **Clarence Matthews Buechler** to its Sales Development department. Buechler was born in Louisville. He obtained his A.B. degree in chemistry at Bellermine College and his M.B.A. degree in business and marketing at the University of Chicago. He is a member of Alpha Delta Phi and the American Marketing Association.

Panellit, Inc., Skokie, Ill., has opened new West Coast manufacturing facilities. Located in Alhambra, Calif., this new factory is staffed to provide customers with experienced instrument and system engineers to aid in the solution of design problems.

Rockwell Manufacturing Co. has added **Marshall G. Cook,** Chicago consultant, as assistant product manager–liquefied petroleum gas products. Cook spent ten years in LPG sales and promotion work for Phillips Petroleum Co. and more recently was associated with R. W. Stafford Co., Chicago, in LPG consulting, design and construction.

In other personnel changes, **Herbert M. Logan,** Tulsa district manager since 1954, has moved to the company's Pittsburgh national headquarters as manager of distributor sales. **Orville W. Barnett,** former assistant to the vice president-new products, has been named Tulsa district manager.

Barnett and Logan both joined Rockwell in 1934, and both have served

R-C centrifugal blowers assure accurate control of volume and pressure

At any speed, Roots-Connersville centrifugal blowers assure uniform delivery of air or gas without the use of receivers. In matching supply to changing demand, this inherent operating advantage simplifies accurate and instantaneous control of volume and pressure.

R-C centrifugals may be direct-connected to high speed electric motors or turbines. Operating speeds may be further raised with speed increasing gears. Occupying a minimum of space and perfectly balanced, with semi-rigid bearing supports to dampen vibration, they do not require special, costly foundations.

Liberal design of diffuser and return passages results in low velocities, normal efficiency even when build-up occurs and exceptionally quiet operation. Operating without internal lubrication, oil-free air is discharged, making it ideally suited for exacting process applications. For complete specification details, write for Bulletin 120-B-14.

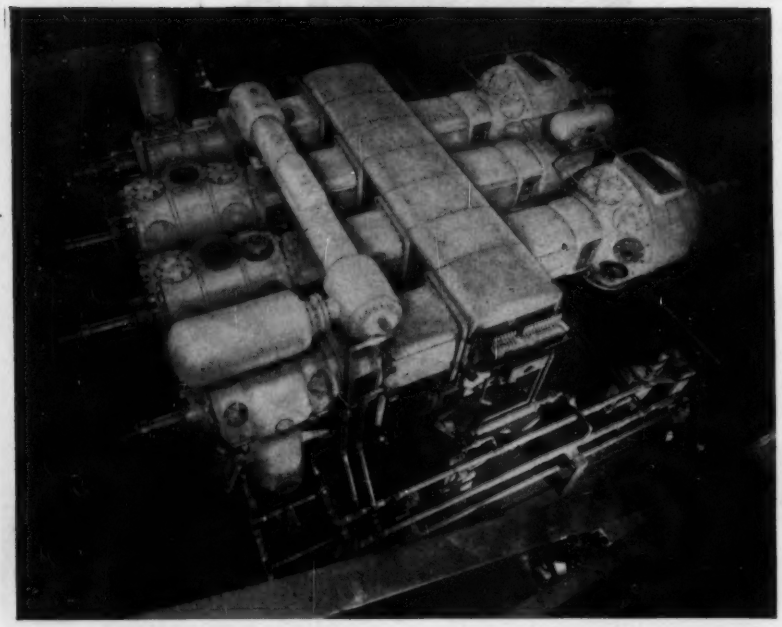
Engineers—unusual career opportunities await you at Roots-Connersville. Address your resume to Professional Employment Manager.

ROOTS-CONNERSVILLE BLOWER

A DIVISION OF DRESSER INDUSTRIES, INC.

357 Crescent Avenue, Connersville, Indiana. In Canada—629 Adelaide St., W., Toronto, Ont.

For more data on advertised products, use Readers' Service Cards, last page.



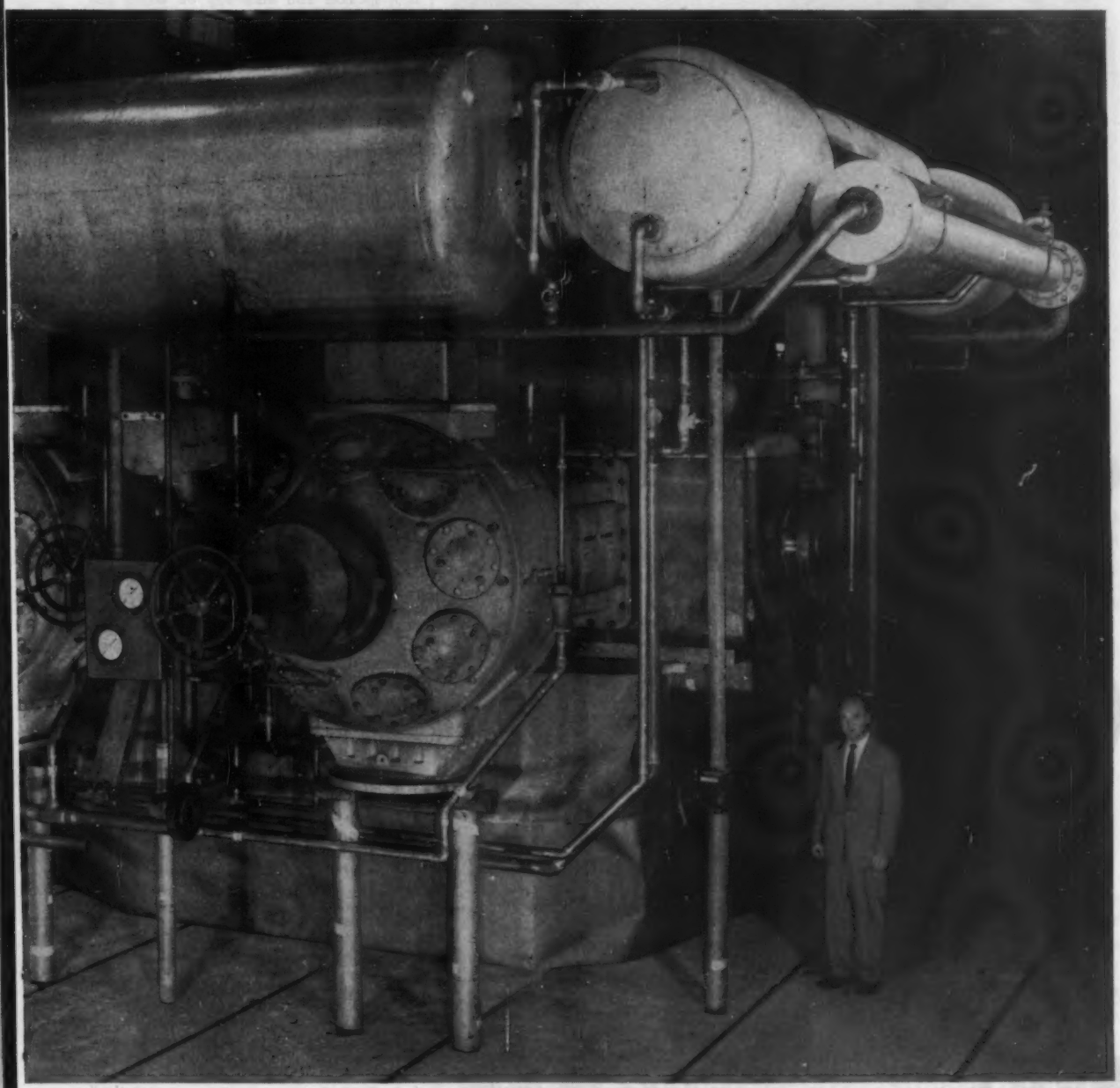
CP BUILDS 'EM BIG

This compressor *is* big! It's one of a pair of 3500 horsepower, five-stage machines built for process work.

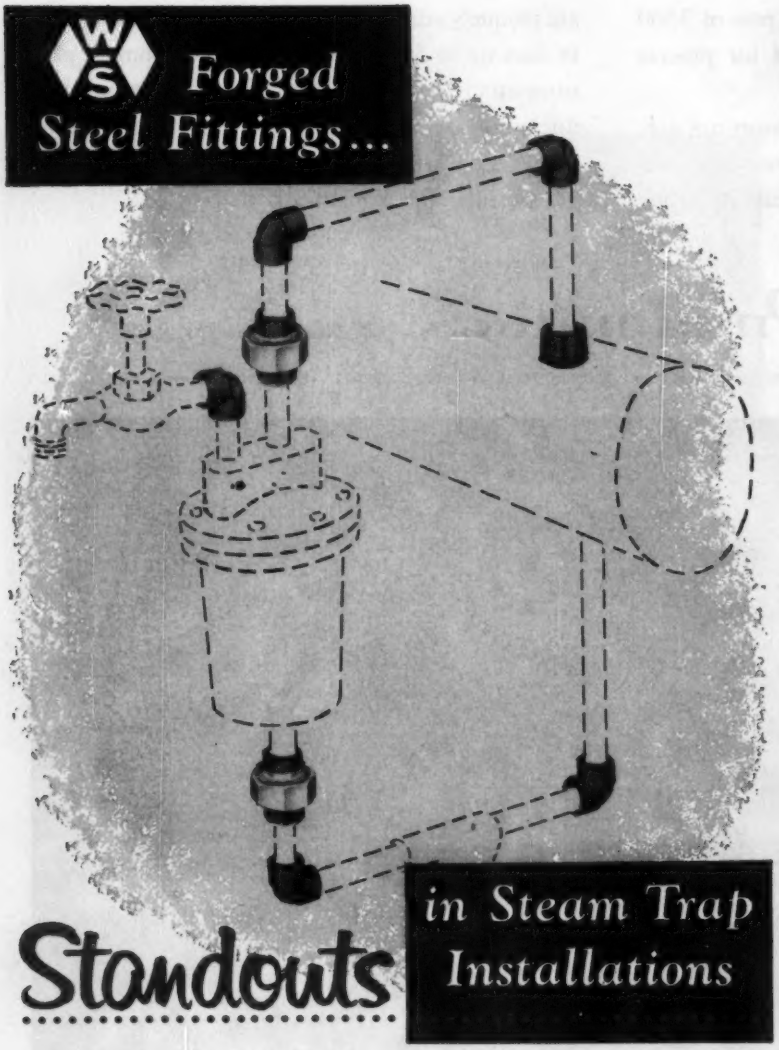
Class FE balanced-opposed compressors are outstanding in every way – high efficiency, proved dependability, moderate ratings, accessibility. They are uniquely adaptable for widely varying conditions, in sizes up to 5000 H.P., for high vacuum or pressures up to 15,000 psig. For synthetic ammonia production. air separation, or other continuous processes, Class FE Compressors offer the utmost in efficiency and availability.

Chicago Pneumatic *8 East 44th Street, New York 17, N. Y.*

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS



Variable volume clearance pockets on all stages of this Class FE Compressor control output. All components, intercoolers and piping were factory-assembled before shipment.



W-S Forged Steel Fittings are a familiar sight around steam trap installations . . . especially when it's high pressure steam. Drop-forged from high strength steel, W-S Fittings readily resist stresses due to pressure, heat, shock and vibration. The W-S line includes 2000, 3000 and 6000 lb. fittings, 3000 lb. forged steel unions, stainless and alloy steel fittings and the new W-S Couplets for connecting to tanks and pipelines. Both screw-end and socket-welding fittings are available to meet your installation requirements.

Ask for our new Forged Steel Fittings Catalog A-3.

Write to Dep't A, W-S Fittings Division,
H. K. Porter Company, Inc., P.O. Box 95, Roselle, N. J.

HKP W-S FITTINGS DIVISION
H. K. PORTER COMPANY, INC.

Suppliers . . .

in various sales capacities in the Tulsa district. Mr. Logan was Tulsa office manager for a number of years and in 1952 became a senior sales engineer specializing in distributor sales. Barnett, a native of Watonga, Okla., and a 1934 mechanical engineering graduate of Oklahoma University, has been a sales engineer in the Tulsa district.

Graver Water Conditioning Co., New York, has announced the appointment of **Vincent J. Calise** as general sales manager. Calise is the holder of both chemical engineering and mechanical engineering degrees and is a speaker and authority on water and waste treatment. He is a licensed professional engineer in New York, and has pioneered in many developments and applications in the water treatment field.

Fischer & Porter Co., has opened an office in the Carib Theatre Building, Clearwater, Florida. **Robert Wenzel,** of F&P's Nutley, N. J. office, will use the Clearwater office to cover the area below Levy, Marion and Volusia counties.

Alco Products Inc. has acquired a new industrial site in Houston as the eventual production center for its petroleum industry equipment business. The company at the same time established its Petroleum Industry Equipment division headquarters, together with the relocation of its district sales offices. Additional internal organizational changes in line with the recent creation of the Petroleum Industry Equipment division also were made public.

Jas. P. Marsh Corp., has announced that **F. O. Pauls** will assume the duties of advertising manager. Pauls has been with the Jas. P. Marsh Corp. for the past fifteen years, starting in the Sales department, and for the past five years he has been assistant advertising manager.

Hills-McCanna Co., Chicago, has announced the appointment of the Burhans-Sharpe Co., 1731 First Avenue South, Seattle 4, Washington, as exclusive representative for Hills-McCanna chemical metering and proportioning pumps and force-feed lubricators in Oregon and Washington.

Flori-Houston Pipe & Steel has appointed **Kenneth R. Notvest** chief research engineer. He will direct all of the welding research and development, quality control, physical and metallurgical testing and non-destructive testing in both plants.

Notvest was educated in the schools of engineering at both Purdue University and Texas A&M, and has held several other important positions before joining Flori Pipe.

Borg-Warner Corp. has elected Henry M. Haase, vice president in charge of engineering and research, as president and chief executive officer of the company's York division. Haase will continue to be a vice president of Borg-Warner but in the future will not direct the parent corporation's research and engineering activities.

Simultaneously the elevation of **Stewart E. Lauer** to the chairmanship of the board of the York division was announced. Lauer had been president of York for 16 years. The Chairmanship of York has been re-

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

linquished to Lauer by **Roy C. Ingersoll**, who has borne that title in addition to his responsibilities as Chairman of the Board of Borg-Warner since York Corp. was merged with Borg-Warner in July, 1956.

Colton Chemical Co., division of Air Reduction Co., Inc., has appointed **H. W. Strong, Jr.**, vice president in charge of operations. A graduate of California Institute of Technology where he received a B.S. degree in science, Strong was with Harshaw Chemical Co. from 1946-52 as development laboratory group leader, catalyst sales department member and assistant to the vice president in charge of manufacturing. He is a member of the American Chemical Society and the Commercial Chemical Development Society. Strong joined Colton Chemical Co. in 1952.

Wolverine Tube, division of Calumet & Hecla, Inc., has appointed **L. G. Fox**, manager of products and named **H. A. Harty**, manager of advertising and sales promotion.

Fox, with the company since 1939 has, for the past several years, been manager of sales service. Harty moves to the new post after having been the firm's advertising manager since 1946.

Conoflow Corp. has appointed **J. Robert Simpson, III**, sales manager. Simpson's background and experience are particularly suitable for his new position. After completing his engineering studies at Lehigh University, Simpson spent several years with a large instrument manufacturer. He served as an officer in the Navy Air Force during World War II, and joined Conoflow shortly thereafter. For more than five years he was intimately involved in the development, application and marketing of many of the company's basic products. In 1951 he became a partner in the firm of J. R. Simpson & Co., Chicago representatives handling Conoflow equipment and allied lines. Simpson remained in this capacity until his recent appointment as sales manager.

Fischer & Porter Co. has just purchased two tracts of land in central Bucks County, Pa. Both tracts, eight miles from the present Hatboro location, are tied in with plans for company expansion.

The larger of the two areas will accommodate buildings for offices, research laboratories and additional production facilities. A nearby 65 acre tract will be developed as a recreational facility for Fischer & Porter personnel.

Allis-Chalmers Manufacturing Co. has named four new distributors for general purpose equipment in Texas, Arkansas and Kentucky.

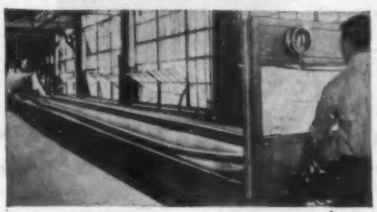
The new distributors are **Atlas Power, Inc.**, 401 N. Scott St., Wichita Falls, Texas; **Clowe and Cowan**, 223 West 4th St., Amarillo, Texas; **Central Electric Supply Co.**, 304 Walnut St., Pine Bluff, Arkansas, and **Griffin Electric Co.**, 3rd and Walnut Sts., Owensboro, Ky.

Leonard N. Herzfeld is president and **Robert T. Priddy**, secretary-treasurer of Atlas Power, which was established in 1956. **A. E. Banasik** is president; **R. G. Mills**, vice president and treasurer, and **Ernest Oakley**, sales manager of Clowe and Cowan, which was established in 1922.

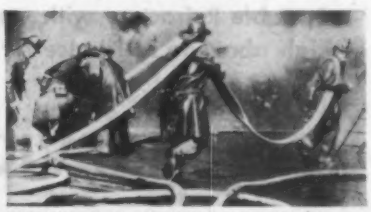
Pictures tell why PETROCHEM does MORE than fight fire

IT'S RUGGED . . . stands up to abrasion, resists weather. PETROCHEM'S oil-resistant Neoprene tube is enclosed in a tough, wear-defying Dacron* jacket. It's a rugged, light, flexible fire hose that wears and wears.

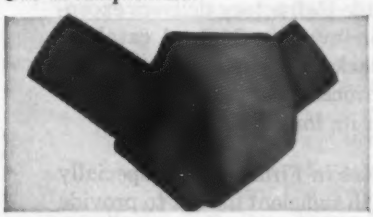
*Reg. T.M. E.I. Dupont de Nemours & Co.



IT'S STRONG . . . strong enough to withstand 500 lbs. pressure and 300°F. temperature.



IT'S OIL AND CHEMICAL RESISTANT . . . fights off deterioration both inside and out.



IT'S FLEXIBLE . . . so flexible it takes tight twists without injury.

IT'S EASILY COILED . . . requires a minimum of storage space.

These are the reasons why it will pay you to consider PETROCHEM fire hose in your safety planning. Your Quaker-Quaker Pioneer distributor provides extra-fast service. See him today. For more information, please write to: *H. K. Porter Company, Inc., Quaker Rubber Division, Philadelphia 24, Pa., or Quaker Pioneer Rubber Division, Pittsburg, Calif.*

HKP

QUAKER RUBBER DIVISION
QUAKER PIONEER RUBBER DIVISION
H. K. PORTER COMPANY, INC.

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Use this "refinery special" Castable Refractory with very high abrasion resistance for —

Long service—low cost

Tests by users and in Laclede laboratories show that Laclede Firmcast Castable Refractory delivers exceptional long-life and economy – in 90% of catalytic regenerators, flue gas stacks and ducts, transfer systems and separators. Firmcast has two special qualities which contribute to its long life.

Hard and dense aggregates in Firmcast are especially selected, then bonded with sufficient matrix to provide excellent abrasion resistance. Because it is "quality-control" processed, Firmcast uses a minimum amount of water for flow-ability and workability.

Next time specify Firmcast Castable Refractory – produced only by *Laclede-Christy Division, H. K. Porter Company, Inc., St. Louis 10, Missouri.*

HKP LACLEDE-CHRISTY DIVISION
H. K. PORTER COMPANY, INC.

Suppliers . . .

Central Electric Supply Co. was founded in June, 1956, and is headed by **Jackson E. Greene. William H. Griffin** is president of Griffin Electric which was established in November, 1929.

Huey

Yopp

Babcock & Wilcox Co. has appointed **Claude L. Huey** manager of its Atlanta district. Huey succeeds **Paul R. Yopp,** who retired after serving as Atlanta district manager for 31 years.

Huey was born in Birmingham, Ala., and joined B&W in 1930 as a student engineer at the former Bayonne, N, J., Works. He was transferred to the Barberton, Ohio, Works the following year and worked in the production department and the process equipment division before returning to Atlanta as a sales engineer in 1934.

Yopp's retirement terminates the longest service period achieved by a B&W district manager or Atlanta district employee. He joined B&W in 1921 as a salesman in Atlanta, and was promoted to district manager on Jan. 1, 1926.

Norton Co., Worcester, Mass., has elected **William H. Perks** treasurer succeeding **Edwin E. McConnell** who is retiring.

Perks is also controller and a director of Norton Co. He will retain these positions in addition to his duties as treasurer. Perks was born in Worcester and is a graduate of Commerce High School and Bryant College. He was a member of the Advanced Management Program, Harvard Business School in 1952. Right after World War II he joined the controllers staff of Norton becoming assistant controller in 1948. In January, 1955, Perks became controller and was elected a director. He was appointed assistant treasurer in 1956.

Nooter Corp. has advanced **Fred O. Koch,** general superintendent to vice president. Koch, who has been with Nooter for 32 years, has been general superintendent and a member of the company's board of directors for the past six years.

Hooker Electrochemical Co., Niagara Falls, N. Y., has announced new appointments among executive and administrative personnel of the former Oldbury Electro-Chemical Co., now the Oldbury Division, Hooker Electrochemical Co. since its consolidation into Hooker.

Dr. Earl L. Whitford, now vice president and director of Hooker, and formerly president of Oldbury Electro-Chemical Co., will coordinate the Hooker research programs at Niagara Falls. Also named were **Dr. Johannes H. Bruun,** director of re-

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To Earn More-Learn More

The knowledge gained through years of work and study by some of the most capable men in the oil industry is set down in the books listed below. Because it is impossible to carry in one's head all the details of his industry, a well-rounded library of reliable data is a definite asset. Not only does it save time, but it often makes his available knowledge of a subject more accurate and up-to-date.

Order some of these books and profit by the experience of others.

ADAMS, ORVILLE
Elements of Diesel Engineering ..... $ 5.00

ALDERS, L.
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LIQUID

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SEPARATION

with "Schuylernit" Mist Eliminators

By the clean, highly efficient separation of entrained liquids from any gas or vapor, "Schuylernit" Mist Eliminators stop costly liquid loss . . . improve product quality . . . increase Chemical and Petroleum vessel performance.

ENGINEERS . . . send for NEW 16 page illustrated manual describing "Schuylernit" Design, Construction and Performance.

REPRESENTATIVES:

GULF COAST
RAWSON & CO.
1223 WAUGH DRIVE
HOUSTON 19, TEXAS

OKLAHOMA
THE CONDIT COMPANY
1011 SOUTH MAIN ST.
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SOUTHERN CALIFORNIA
BUSHNELL CONTROLS & EQPT. CO.
5137 W. JEFFERSON BLVD.
LOS ANGELES 16, CALIF.

specialists in liquid/vapor separation

SCHUYLER

MANUFACTURING CORP., NO. ARLINGTON, N. J.

Suppliers . . .

search and development; **Dr. Walter H. Prahl**, director of research and development, Durez Plastics division; and **Dr. James H. Brown**, manager of research and development, Oldbury division.

U. S. Industrial Chemicals Co. has named **Lawrence C. Byck, Jr.** manager of heavy chemical sales. Byck will have responsibility for sales of heavy chemicals, including nitrogen products, phosphoric acid and sulfuric acid.

Byck, a graduate of Yale University, has been assistant to the manager of chemical sales during the past four years, and has been with the U.S.I. organization since 1945. Before he joined U.S.I., he was employed by Carbide and Carbon Chemicals Co.

California Steel Products Division, ADSCO Industries, Inc., Richmond, Calif., has appointed **West Engineering Sales Co.**, Whittier, Calif., as its engineering sales representatives for Southern California, Arizona, and New Mexico. West Engineering is managed by **C. N. Cannon** and **F. S. West.** Both men have been closely associated for a number of years with the design and engineering of petroleum and chemical processing units.

Detectolab, Inc., Chicago, Ill., affiliate of Borg-Warner Corp., has been consolidated into BJ Electronics, Borg-Warner's electronics division at Santa Ana, Calif., it was announced by **John R. Harkness,** vice president of BJ Electronics.

Delta Tank Manufacturing Co. has appointed **Howard Maddox** office manager for the company's Oilfield Equipment division branch in Laurel, Miss., and **S. C. Hewitt** field sales engineer for the Laurel branch.

Hewitt has served in sales management positions in the oilfield equipment industry for nearly 30 years. Maddox was active in finance company work prior to joining Delta Tank.

Flori-Houston Pipe & Steel has appointed **J. F. Huitt** chief engineer. Huitt will operate from the general headquarters of the

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

new organization in St. Louis. Before becoming chief engineer Huitt had been manager of engineering sales and later production manager at Flori. Previously he had headed his own engineering consultation firm. He took his engineering work at Washington University (St. Louis) and Missouri University.

Roots-Connersville Blower Division of Dresser Industries, Inc. has promoted **Glenn H. Crocker** to manager, factory sales from chief application engineer, centrifugal equipment. He assumes responsibility for all sales application engineering functions at the headquarters in Connersville. A native of Kansas, he is a member of the American Society of Mechanical Engineers and of the Compressed Air and Gas Institute.

Joseph L. Hylton has been promoted to the newly created post of manager, market research. He previously held the position of assistant to the sales manager and has been with the company since 1947. A native of Indiana, Hylton is a member of the American Marketing Association and the National Industrial Advertisers Association.

Foster-Wheeler Corp., heavy construction and engineering firm, has taken more than one-fifth of all the office space in the 38-story blockfront skyscraper under construction at 666 Fifth Avenue in New York City.

The lease involves five of the largest floors in the building, with a total floor area of more than 200,000 square feet and an aggregate rental of $21.5 million over a 20-year period.

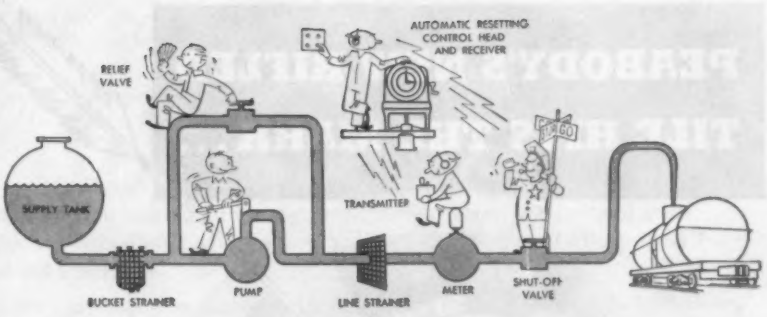
Crane Packing Co. has announced four executive promotions. These are: **Carl E. Schmitz** to executive vice president from his former capacity as vice president in charge of sales; **Vance E. Vorhees** to vice president in charge of sales from assistant general sales manager; **B. H. Stenberg** to vice president in charge of manufacturing from works manager; and **E. H. Stubenrauch** to assistant general sales manager from divisional sales manager.

The Patterson Foundry and Machine Co., East Liverpool, Ohio has completed a reorganization of its home office sales division. The reorganization is part of an overall program to expand the company's activities.

Appointed to the newly created position of assistant to the director of sales is **Glenford M. Shibley** who recently joined the company. Formerly associated with Osborn Manufacturing Co. of Cleveland, Shibley joins Patterson with a broad background in sales administration, sales training and promotion.

Product group managers, technical specialists in the application of processing equipment, have been named to head the following product divisions: **C. G. Keirnan,** manager, Mixing and Drying; **J. E. Wright,** manager, Size Reduction and Classification; **E. W. Stephenson,** manager, Ceramics and Replacement Components; **R. W. Campbell,** manager, Process Systems.

R. Jebens has joined Patterson to fill the position of manager of application engineering. **R. B. Mack** was appointed



TYPICAL REMOTE CONTROL FLUIDOMETER SYSTEM

For Use Where Valves Must Be Located In Hard-to-get-to Places

This animated picture illustrates a typical remote control Fluidometer application. Remote control of this general type is recommended when plant conditions or arrangement make direct control impractical or impossible. With a system of this type the Fluidometer control head can be located away from the meter. Shown at the left is the automatic resetting control head, which controls the operation of the shut-off valve to give completely automatic batching. Available either jacketed or unjacketed—"tailor made" to fit your needs. New Bulletin Fl-56 will be sent on request. For information on jacketed pipe and fittings write for Bulletin J-56.

HETHERINGTON & BERNER INC. · *ENGINEERS-MANUFACTURERS*
710 KENTUCKY AVENUE **INDIANAPOLIS 7, INDIANA**

NOW! ***The handling of liquefied petroleum gases, refrigerants and other light non-viscous liquids*** **is a CINCH!**

TYPE Z4
AURORA® APCO *Process* PUMPS

New and difficult applications in modern industry pose a challenge to pump designers. Aurora engineers have met this challenge completely with the APCO TYPE Z4 Process Pumps—which combine the ideal turbine-type features, special metals where required, single mechanical seal and other latest design features for SURE RESULTS. We invite your inquiry.

SPECIAL METALS

APCO'S are obtainable in any machineable alloy. Small amounts required. Result: ECONOMY.

DISTRIBUTORS IN PRINCIPAL CITIES

AURORA PUMP DIVISION
THE NEW YORK AIR BRAKE COMPANY
84 LOUCKS STREET • AURORA • ILLINOIS
EXPORT DEPARTMENT, AURORA, ILLINOIS, CABLE "NYABINT"

For more data on advertised products, use Readers' Service Cards, last page.

PEABODY'S NEW RIFLED TILE HITS THE MARK...

from full capacity to minimum capacity instantaneously, with complete stability and safety, burning gas.

A new, basic concept of gas firing, Peabody's rifled tile maintains ignition under the most adverse conditions with assured safety, even when controls break down or go out of adjustment. Specially designed, this rifled tile develops continuous, low-velocity eddy currents, in the rotating air and fuel mixture, which rapidly ignite and serve as continuous, *positive* pilots. Available on new or old Peabody Ring-fired Gas Burners—permits minimum load on gas without regard to wind-box pressure settings or gas heating value—and with complete safety and stability. Complete details on request.

PEABODY ENGINEERING CORPORATION

232 MADISON AVENUE, NEW YORK 16, N. Y.

OFFICES IN PRINCIPAL CITIES

PEABODY LIMITED • LONDON, S.W. 1, ENGLAND

6-385-1

Suppliers . . .

manager of customer services and will be assisted by **W. O. Sutherland** and **W. C. Sturgeon** as customer service specialists.

E. H. Ford will continue as manager of the export division, a position he has filled for a number of years. Named as manager of advertising and sales promotion is **R. L. Custis.**

Wolverine Tube, Division of Calumet & Hecla, Inc., has appointed **William Bothwell** sales representative in Kentucky, Southern Indiana and surrounding area. He replaces **Jack Sheehan,** who was recently promoted to manager of wholesaler sales.

Formerly sales representative in New Jersey and more recently Aluminum office representative in Wolverine's general sales offices, Bothwell will headquarter in Louisville.

Layne & Bowler, Inc., has named **William H. Reeves** president of the company. **James I. Seay** has been named chairman of the board. He has been president since 1945. Reeves has been vice president for the past 15 years.

Frank T. Quinn was named vice president in charge of manufacturing and **A. O. Fabrin,** vice president in charge of engineering. **L. G. Ost** was re-elected secretary-treasurer and **M. H. Sandstrom,** assistant secretary-treasurer.

American Meter Co. has named **Eugene D. Rouse** and **Jack S. Coldren** sales representatives for the Garland, Texas, and Fullerton, Calif. sales districts. Rouse was formerly with the Federal Bureau of Investigation and Boeing Airplane Co. He is a graduate of Denver University and served in the U. S. Navy in World War II.

Prior to joining American Meter, Coldren was with Burlington Mills Co., Los Angeles. He is a graduate of Los Angeles State College.

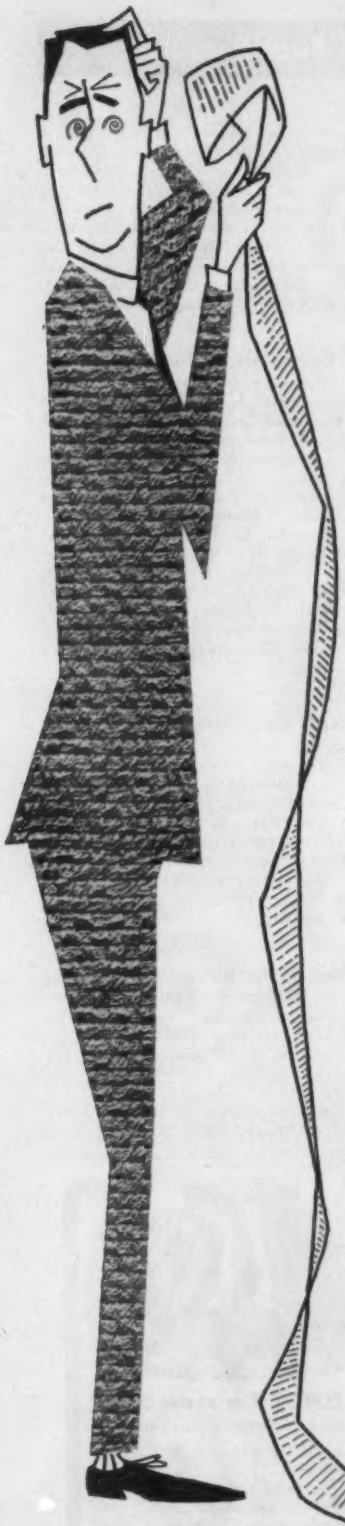
Babcock & Wilcox, Boiler division, has reorganized its manufacturing department. Major responsibilities in the department, which has its headquarters at the company's Barberton, Ohio Works, are assigned to:

O. R. Carpenter, will continue as executive assistant and manager of the quality control section. **G. J. Hartnett, Jr.,** has been named manager of the industrial engineering section in charge of all planning functions for all plants of the department. Formerly he had been superintendent of the Barberton Works.

Ethyl Corp has appointed **George Krieger** as special assistant to **James E. Boudreau,** director of public relations. Krieger, who has been associated with Ethyl since 1929, will be in charge of the company's public relations activities in the agricultural field.

Krieger brings to his new assignment many years of experience in the farm tractor field and a broad knowledge of agricultural problems. In the 1930's, he assisted in the introduction of the gasoline-powered farm tractor, and has since been instrumental in its growth to its position today. Meanwhile, he filled a number of sales and technical assignments for Ethyl Corporation in the farm equipment and agricultural chemical fields. During World War II, Krieger served as deputy director and later as director of the Farm Machinery and Equipment division of the

For more data on advertised products, use Readers' Service Cards, last page.



You say you've got a problem, Mister?

You say you're looking for the right steel tube analysis to withstand acids, corrosives, oxidation, high pressures and high temperatures? Mister—you *have* got a problem.

But don't give up. You can get help. National Tube has been studying refinery problems of all kinds for over 60 years. We've kept case histories of these problems and their solutions on file, and from this vast, comprehensive knowledge we've developed over two dozen different steel analyses—answers to almost every refinery tubular problem in the book.

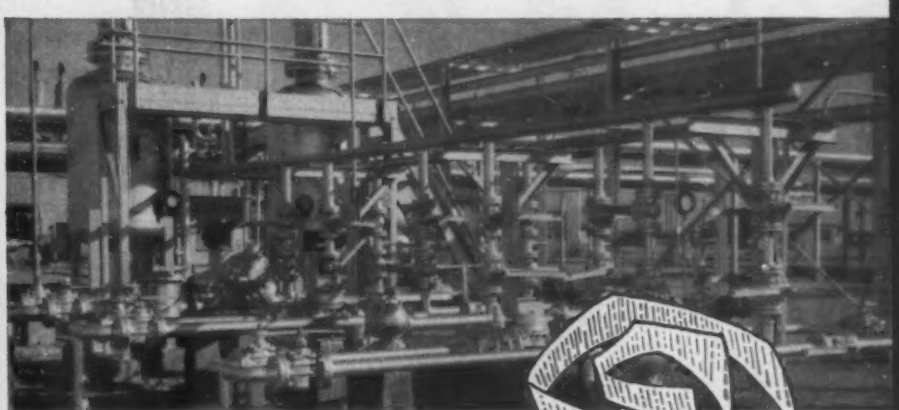
Every one of these analyses has been tested and retested in actual refinery service so that we know what can be expected of each. And, in addition to the 24 analyses shown here, other chemical compositions are available in tubular products, and a wide variety of temperature problems are under study.

So, bring your problem to us. Our expert Mill Service Force will do everything it can to help you find a solution. This force is also available for field consultation. And there is a good chance we can save you money, by finding a good alloy, at low cost, that will meet all the requirements of the job.

Write to National Tube Division, United States Steel Corporation, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

EXAMINE THESE TWO DOZEN DIFFERENT NATIONAL TUBE ANALYSES:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni



NATIONAL TUBE DIVISION, UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.
(Tubing Specialties)
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

NATIONAL SEAMLESS PIPE AND TUBES

WALLS WITHOUT WELDS

U N I T E D S T A T E S S T E E L

MANNING & LEWIS ENGINEERING CO.
28-42 OGDEN ST. NEWARK 4, N.J.
WORKING PRESS:- SHELL TUBES
UNIT NO. JOB NO.

HEAT EXCHANGE and PROCESS EQUIPMENT

THIS NAMEPLATE IS YOUR GUARANTEE OF QUALITY

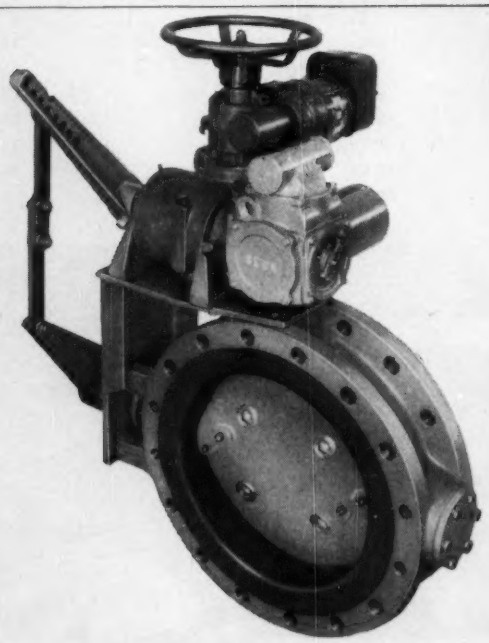
- Condensers
- Evaporators
- Jacketed Kettles
- Ribbon Mixers
- Agitators
- Reactors
- Pressure Vessels
- Heat Exchangers
- Reboilers

READY TO SHIP—MORE THAN 9 TONS OF EFFICIENT VAPOR COOLING SERVICE IN ONE PACKAGE

This 21 foot, all carbon steel heat exchanger is protected against tube side to shell side leakage by double tube sheets at each end. In addition to the tubes being rolled into each tube sheet they are welded to the outside tube sheets for maximum strength and protection.

Units such as this by operating efficiently year after year, in a wide variety of applications, offer the strongest possible testimonials to Manning and Lewis "know how" in design, engineering and fabrication for the process industries.

Manning & Lewis Engineering Company
DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT
28-42 OGDEN STREET NEWARK 4, NEW JERSEY
M&L



Automatic Control and Tight Shut-Off

18"—125# Neoprene-lined butterfly valve; equipped with bronze disc, Monel metal shaft, electric motor operator and auxiliary handwheel.

W. S. Rockwell butterfly valves are built in all sizes for any required condition of pressure, temperature and nature of fluid handled. Write for Catalog.

W. S. ROCKWELL COMPANY — 2367 Eliot Street, Fairfield, Connecticut
BUTTERFLY VALVES • SLIDE VALVES • AUTOMATIC VALVES

Suppliers . . .

War Production Board and also was a special assistant to Donald M. Nelson, Chairman of the War Production Board.

Krieger was a vice president of the Society of Automotive Engineers, chairman of the Agricultural Development Committee of the American Petroleum Institute, and chairman of the Fuels and Lubricants Committee of the American Society of Agricultural Engineers.

Radio Corp. of America has appointed managers for eight service regions. They will be responsible for all field service and installation activities of the Technical Products department.

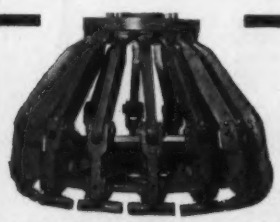
The appointments and headquarters locations are:

B. D. Bachin, Eastern region, New York; **M. E. Wheaton**, Mideast region, Philadelphia; **C. L. Swinney**, Southeast region, Atlanta; **W. W. Gilreath**, Southwest region, Dallas; **E. D. Van Duyne**, Westcentral region, Kansas City; **F. W. Hamre**, Central region, Chicago; **H. M. Madison**, Western region, Hollywood; and **H. E. Frisbie**, Eastcentral region, Cleveland.

The Bristol Co., Waterbury, Conn., has opened a new branch factory and warehouse in Houston. The company was founded at its present New England headquarters in 1889, then the heart of industrial America. Later, as industry and commerce pushed westward, a branch factory and repair laboratory were established at Chicago. Still later, another branch was opened in San Francisco, as that area developed industrially.

W. C. Norris Manufacturing, Inc., has elected **William L. Butler** president, according to an announcement made by **E. C. Bolger**, retiring president. Butler joined Norris in 1935 and, prior to his election as president, was executive vice president.

Bolger was president of the company from 1946 through 1956, having joined



BARRETT automatic
Filling and Crimping Equipment
for handling greases and other viscous fluids.
- No operator required.
- 100% air operated.

Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

BARRETT Manufacturing Co.
P. O. Box 8096, Houston 4, Texas

Suppliers . . .

W. C. Norris following his release from the Navy. His resignation was effective December 31, 1956.

Other officers of the company are **G. W. Davidson,** vice president-sales; **R. A. Colgin,** vice president-manufacturing; and **Charles Huffman,** secretary-treasurer.

Changes of Address

Misco Fabricators, Inc., designers, builders and fabricators of heat resisting alloy and stainless steel equipment, has relocated in Marysville, Mich., in the former Dow Magnesium Co. building. Misco, a division of Michigan Industries Co., Detroit, occupied a section of the National Food warehouse building at 3564 Toledo Avenue in Detroit, recently destroyed by fire.

Fisher Governor Co.'s sales representative for Boston and New England area is Clarence B. Petty & Co., 50 Kearney Road, Needham Heights 94, Mass. Other sales engineers that will assist Clarence Petty are Walter Taylor and Steve Lord.

Peabody Engineering Corp. New York, has just announced the opening of a Michigan office at 7338 Woodward Ave., Detroit.

The Detroit office, under the direction of **J. F. Mac Eachern,** will offer sales and service facilities to Peabody customers in the area. Mac Eachern will bring to the new branch office operation experience with Peabody Engineering which includes more than 12 years in design, engineering, service and sales.

Sarco Company, Inc. and Sarcotherm Controls, Inc., San Francisco, have moved its office and warehouse to new and larger quarters at 1485 Bayshore Blvd. **J. Spear** is manager of this branch office. The main sales office is located in the Empire State Building, factory in Bethlehem, Pa.

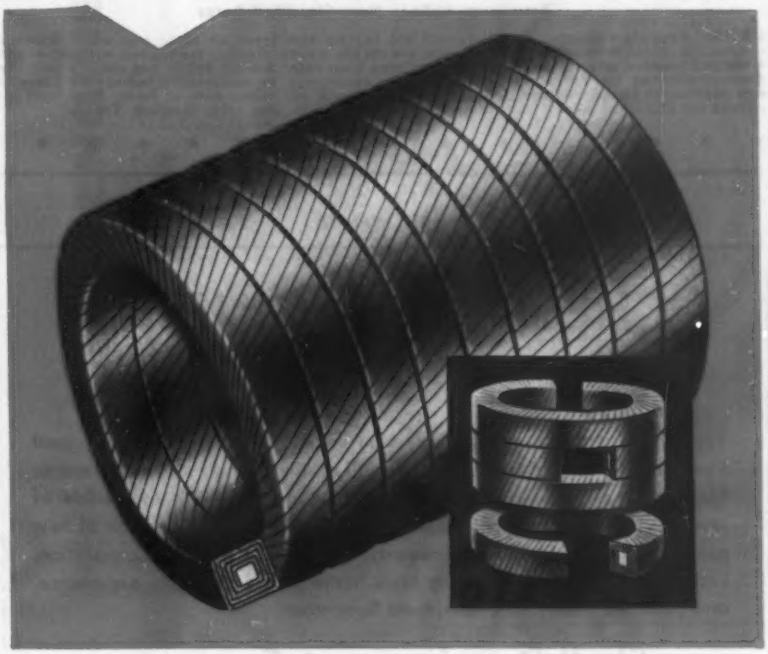
Welding Fittings Corp., New Castle, Pa. has opened its Los Angeles office at 4781 East Third Street, Los Angeles 22, Calif. **Howard W. McNutt,** Welding Fittings Western district sales manager, will be in charge of the office.

Metal & Thermit Corp., New York, has opened warehousing and sales office facilities at Houston. A complete stock of arc welding electrodes and a new line of iron powder hard facing rods will be maintained at the Houston Terminal Warehouses, 701 N. San Jacinto St., with offices at the same location. **John A. Watson, Jr.** will be in charge of the operation.

Bigelow-Liptak Corp., has moved its engineering, sales and general offices to new, company-owned quarters at 13300 Puritan Avenue, Detroit 27, Mich., announced **H. S. Ford,** vice president and general manager. Bigelow-Liptak is a producer of furnace enclosures for all types of industrial applications.

Armstrong Cork Co. has acquired a new sales office and warehouse building for its Cincinnati district offices. The modern facilities are located at 1057 Meta Drive, Cincinnati 37. They were built by the Penker Construction Co. for long-term lease to Armstrong.

BELMONT
Semi-Metallic* Packings



for temperatures to 1000°F

Here is a packing that is "custom made" to withstand high petroleum temperatures—and to remain flexible and efficient as a sealing medium throughout its longer life.

Use Belmont Twisted Aluminum Foil Packing on centrifugal shafts, reciprocating rods, valves, stillnecks and other equipment handling hot crude and petroleum distillates at temperatures up to 1000°F.

Available in spiral or ring form.

* Twisted, spirally-wrapped Aluminum Foil Packing with or without dry braided asbestos core. Series 2080.

Ask your BELMONT *Packing Distributor or write for Cat. No. 56.*

The Belmont Packing & Rubber Co.
Butler & Sepviva Sts., Phila. 37, Pa.

BELMONT

For more data on advertised products, use Readers' Service Cards, last page.

CLASSIFIED ADS

PETROLEUM REFINER

Classified Ads

Petroleum Refiner New Classified Rates

RATES: **Regular Classified** (undisplayed) set in this size type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads**, set in suitably larger type with ruled border, $12.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Petroleum Refiner, P. O. Box 2608, Houston, Texas.

* * * * * * * * * * * * * * * * *

HELP WANTED

CHEMICAL ENGINEERS
PROCESS ENGINEERING

Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

Shell Development Company

Emeryville 8, California

ENGINEERS
Design & Construction

NEWLY FORMED SUBSIDIARY OF MAJOR OIL COMPANY has immediate openings for graduate engineers experienced in petrochemical and refinery design and construction. Due to expansion of petrochemical activities, unusual career opportunities are available for qualified men at junior, intermediate and advanced employment levels in applicable engineering work.

Positions offer stable employment, a liberal, well balanced group of employee benefit plans and salaries commensurate with training and experience.

Forward complete employment resume together with recent photograph, details concerning age, marital status and education background to the Employment Office, P. O. Box 1712, Brownsville, Texas. All replies will be confidential and interviews for qualified applicants will be arranged at the plantsite.

AMOCO CHEMICALS CORPORATION

(Subsidiary of Standard Oil Company (Indiana))

HELP WANTED

ENGINEERS

Heat
Exchangers
Pressure Vessels

Men with refinery or chemical plant experience who are familiar with process design and estimating of heat exchangers and fractionation columns. Responsible positions with an outstanding manufacturer. Good salaries. Profit-sharing retirement plan. Allowance for moving to Southern California. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

Be Sure To Check This Month's Classified Section in REFINER

Need Engineers - Technical Personnel? Try a Classified Ad in Petroleum REFINER.

QUICK! ECONOMICAL! RESULTFUL!

Help Wanted! Classified Ads in Petroleum REFINER get the job done.

Free to PETROLEUM REFINER Subscribers

Write for free booklet on preparation of articles for PETROLEUM REFINER, the technical press generally, as well as papers for technical meetings. Use Readers' Service green cards in the back of this issue. Write on the card "Free Author's Booklet," fill in name, address and mail. No charge, no obligation.

HELP WANTED

■ REFINERY CHEMIST. Independent oil company needs experienced Chemist or Chemical engineer, preferably with refining background. B. S. Degree. Opportunity for Growth with rapidly expanding midwestern company. Write Box 263-R, c/o PETROLEUM REFINER, Houston 1, Texas.

■ MECHANICAL ENGINEER. For Major Oil Company in Mid-Continent area. Must be graduate engineer and have six to ten years supervisory and master planning experience in Refinery Mechanical and Maintenance Department. Address all replies giving age, education, resume of experience and salary expected to Box 260-R, c/o PETROLEUM REFINER, Houston 1, Texas.

■ PROCESS ENGINEER with thorough technical training and minimum background of eight years refining and hydrocarbon processing experience with special emphasis on catalytic reforming and petrochemicals. Send complete record of education, experience, and minimum salary expected. Write Box 259-R, PETROLEUM REFINER, Houston 1, Texas.

REFINERY ENGINEER—Process engineering position with large independent company operating in Mid-Continent area. One to five years experience desired. State qualifications and give salary requirements. **Cooperative Refinery Association, Box 7305, Kansas City 16, Missouri.**

PROCESS ENGINEER

for progressive major oil company. Must be graduate Refinery or Chemical Engineer. Liberal company benefits. Address all replies giving age, education, resume of experience and salary expected to Employee Relations Dept., Box 2039, Tulsa, Oklahoma.

"Graduate Petroleum Engineers needed to fill permanent position on Petroleum Engineering Faculty at Southwestern Louisiana Institute in Lafayette, Louisiana. M.S. or PhD. preferred, but will consider candidate for these degrees. Salary & rank depend on education and experience. Write G. G. Varvaro, Head Department of Petroleum Engineering, S.L.I. Lafayette, Louisiana."

REFINERY ENGINEER—Process engineering position with large independent company operating in Mid-Continent area. One to five years experience desired. State qualifications and give salary requirements. Box 255-R, PETROLEUM REFINER, Houston, Texas.

Sales Engineer

Manufacturers representative requires young chemical or mechanical engineer with process experience to sell process equipment to Gulf Coast Refineries and chemical plants. Participate substantially in steady growth of small company. Replies confidential. Give short resume for interview.

THE RAINEY COMPANY
P. O. BOX 6453, HOUSTON 6, TEXAS

POSITIONS WANTED

■ PROCESS-PROJECT ENGINEER—Nine years Design and Operations including six years with major contractor. Experience includes gasoline and chemical plant process design, engineering, and startup. South or southwest preferred. Box 262-R, PETROLEUM REFINER, Houston 1, Texas.

"Sales engineers handling metropolitan New York and New Jersey with strong contacts among refiners and refinery contractors can get the business for one additional good account." Box 258-R, c/o PETROLEUM REFINER, Houston 1, Texas.

HELP WANTED

ENGINEERS

Chemical
Mechanical
Petroleum

Assignments in our Chemical Engineering Department cover application of processes to a wide variety of industrial plants, complete integrated refineries and chemical processing centers. The work includes coordinating of chemical engineering, selection and design of process equipment and startup of completed plants. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

Save on Your
INDUSTRIAL
TRACK
FULLY
GUARANTEED
FOSTER
QUALITY
RELAYING RAILS
Handle more cars better—cost less to install and maintain. Foster stocks all Rail Sections 12# thru 175#, Switch Material and Track Accessories.
SEND FOR CATALOGS
RAILS - TRACK EQUIPMENT - PIPE - PILING
L B FOSTER co.
PITTSBURGH 30 • NEW YORK 7 • CHICAGO 4
ATLANTA 8 • HOUSTON 2 • LOS ANGELES 5

Technical Positions Available

1. Electrical Engineer. Several years design 10,200
2. Mechanical Engineer. Research and development 10,000
3. Sales Engineer. Metallurgical background 9,600
4. Chemical Engineer. 2 or 3 years processing 8,400

Many other positions available locally and abroad.
Many companies pay our fees on technical jobs.

DIXIE EMPLOYMENT SERVICE
505 South Coast Bldg., HOUSTON
CA 2-9537

HELP WANTED

EHRHART & ASSOCIATES, INC.
Engineers and Constructors

Engineers
PROCESS • PROJECT
MECHANICAL
for
SAN FRANCISCO
and
LOS ANGELES

Men with 5 to 15 years experience in design and design supervision of process plants, refineries or chemical plants are required for small rapidly growing company with opportunities at senior levels. Company is engaged in engineering-construction projects for major West Coast Companies.

Company paid hospitalization, life insurance and vacations.

Personal interviews will be arranged.

EHRHART & ASSOCIATES, INC.
Engineers and Constructors
417 SOUTH HILL STREET
LOS ANGELES 13, CALIFORNIA

ENGINEERS

Process

Assignments in our Process Engineering Department for engineers with three to six years experience range from integrated refineries and chemical plants through all types of individual process units. The work includes heat and material balance, and computations for unit operations such as fractionation and heat-transfer. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

CLASSIFIED ADS

HELP WANTED

ENGINEERS

Process

Assignments in our Process Engineering Department for engineers with eight or more years of experience cover process design, selection of processing steps, and economic evaluation of processes. Other work may include market analysis, industrial surveys, and technical assistance to sales. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

HELP WANTED

DESIGNERS

Piping

Assignments in our Piping Engineering Department for designers with three or more years experience range from integrated refineries and chemical plants through all types of individual process units. Assignments include arrangement of plant equipment and facilities, layout of process and utilities piping. Send a summary of your experience and interests to F B Stratford, Head of Personnel, C F BRAUN & CO, Alhambra, California.

HELP WANTED

Growth Opportunities

Expanding independent refinery in Minnesota needs:

Mechanical Engineer
Chemical Engineer
Electrical Engineer
Instrument Engineer

Positions offer above average growth prospects in a refinery that has expanded steadily for past ten years. Salary and employee benefits excellent. Ideal family location. All recruitment expenses will be paid by the Company. Send resume to:

George Armistead and Company
1200 Eighteenth Street
WASHINGTON 6, D. C.

ESSO EXPANSION PROGRAM

PROVIDES OPPORTUNITIES

IN

COST ENGINEERING

Career positions available for graduate engineers in long range expansion program. Work involves technical aspects of cost estimating, development of estimating methods and cost analysis for all types of petroleum and chemical processing plants.

Excellent opportunities to learn many aspects of process and mechanical design while contributing to selection of optimum equipment for world wide expansion program.

High scholastic rating and ability to grow with organization particularly desired. Prefer one to five years engineering experience. Salary commensurate with experience and qualifications.

All inquiries will be considered promptly and held confidential.

Letter should give full details of education, experience, salary desired, availability date and references.

ESSO RESEARCH AND ENGINEERING COMPANY

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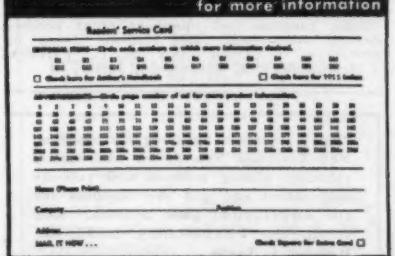

* see inside back cover

Suppliers . . .

ALCO Products, Inc. has announced the appointment of **T. I. Equipment, Inc.** of Cleveland as its exclusive agent in Northeastern Ohio. The appointment was announced jointly by **A. T. Lawrance**, general manager of field sales for ALCO, and **B. B. Farmer**, senior partner of T. I. Equipment, Inc.

E. I. du Pont de Nemours & Co., Inc. has named **James G. McIlhiney** a district manager in the company's Petroleum Chemicals division. He will take over the newly created Denver district.

McIlhiney was previously in Philadelphia where he was a salesman of petroleum additives. A mechanical engineering graduate of Cornell University, he joined Du Pont in 1947 and has been a sales representative to the refining industry on both the East and Gulf coasts. He also served for a year in the new product development group in the Wilmington office.

Mixing Equipment Co., Inc., Rochester, N. Y., has promoted **Lewis H. Mahoney** from assistant sales manager to director of technical sales. **James A. Mason,** former senior application engineer, has been advanced to chief application engineer, and **Donald M. Rowe** has been named senior application engineer.

Wolverine Tube, Division of Calumet & Hecla, Inc., has appointed **John V. Betz** sales representative in the New York area. Formerly with Gar Supply Co. of Long Island, Betz will headquarter in Wolverine's New York office.

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.
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- FIREPROOFING
- STACKS, BREECHINGS.
- REFRACTORY TURN AROUNDS.
- CONCRETE AND STEEL SANDBLASTING
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- CONCRETE RESTORATION

Write for estimates on your proposed project

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RASCHIG RINGS
has proved outstanding as Tower Packings . . . Decrease Operating and Production Costs
Metallo is your Primary Source for standard and custom metallic Raschig Rings. We design, produce and deliver, for ordinary and difficult extraction processes, directly from this one factory.
Metallo Metallic Raschig Rings materially decrease operating and production costs on a wide variety of reaction and scrubbing towers, rectifying columns, extraction systems and other industrial processes.
Calculated in efficiency, long life and the amount of contact surface per cubic foot, Metallo is your best buy. Metallo Metallic Raschig Rings come in a wide variety of standard sizes.
AVAILABLE IN ALL WORKABLE METALS.
CUSTOM PRODUCED TO YOUR MOST EXACTING SPECIFICATIONS.
Prompt Delivery on All Quantities.
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METALLO GASKETS for HEAT EXCHANGERS
We are prepared to supply gaskets for Heat Exchangers and similar equipment made of metal jackets and asbestos filler, compressed asbestos sheet or solid metal. They can be supplied in any size up to the limit of transportation facilities.
Specially constructed Metallo Gaskets are made for Heat Exchangers with a variety of metal jackets and asbestos filler in any size. They are also cut from solid sheet metal.
We also supply METALLO metallic LESSIG RINGS to act as efficient liquid distributors by eliminating cross flows in all workable metals.
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NEW BRUNSWICK, N. J.
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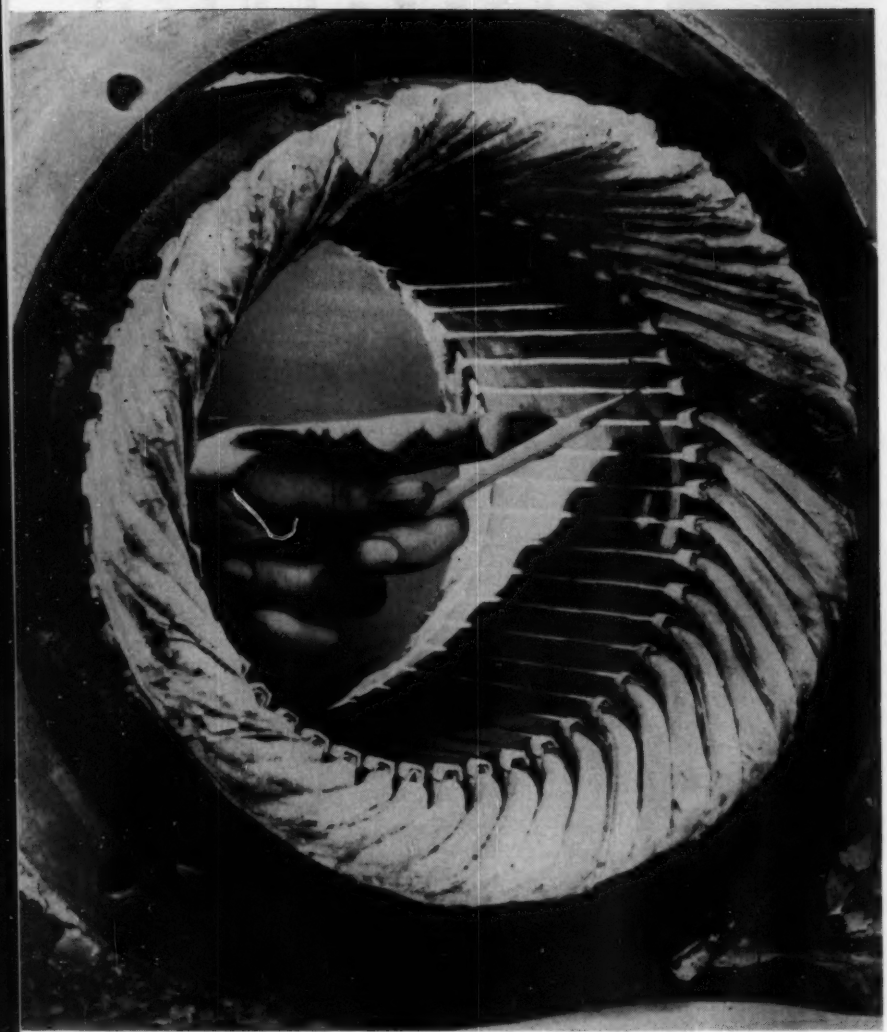
For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment . . .

. . . and Manufacturers Literature



Silicone Insulated Motor Runs for 60,000 Hours

After the equivalent of 5787 years, a much-abused motor finally broke down a few weeks ago—and one of the longest and most fundamental motor testing programs in industry was almost over.

In all there were eight motors: 10 hp, 1190 rpm, 3 phase induction units, fitted with special end-bells and asbestos shields to isolate the bearings. Six units were insulated with silicone bonded and impregnated materials. For comparison, two were class B insulated.

All eight motors were generator-loaded to produce average copper temperatures ranging from 200 C. (392 F.) to 310 C. (590 F.). Operating time at temperature was divided into heats, each a 25th of the motor's estimated maximum life. The heats were alternated with 24-hour conditioning periods at 100 percent relative humidity.

It was anticipated that the test would run about a year or so. Both class B units did fail and catch fire just about as expected, and the silicone insulated motors showed an abrupt drop in wet insulation resistance at the predicted times as well. But contrary to expectations, the drop was not followed shortly by total insulation failure. Instead, the motors kept right on going. The 310-degree motor, for example, was expected to fail within a week or so. It lasted over seven months. So did one of the 300-degree motors, and the other held on for a year. When they finally did break down, it was due to copper oxidation, not to insulation failure.

Gradually it became apparent that the "failure mechanism" of silicone insulation was far different than that of organic materials. Even after the varnish had crazed it still maintained a good bond, holding the other components in place. It never evolved into a conductor, because of its silica backbone. And it stayed hydrophobic.

After 60,000 hours at 240 C., the original silicone varnish has evolved into something like glass, but its bond strength, insulation resistance, and water-repellency are still good. The motor failed because the heat-warped rotor dragged on the stator (note rub-marks), pulling laminations until one pinched through a slot, as indicated. Dow Corning Corporation.

Circle E1, green card, last page

Gas Chromatography

An article on gas chromatography, a new technique rapidly coming into wide use in chemical research, has just been published.

Entitled "Hot Air Unlimited," the article is one of a series of "Research Comments" published and widely distributed to chemical and allied industries.

Written by Dr. Donald A. B. Mackay, associate director of research, the article traces the historical background, the theory, the practice, and the potentialities of this important new addition to the armament of chemical research. Evans Research and Development Corp.

Circle E2, green card, last page

Insulation Resists 2000 F.

A new resinous compound that will insulate a metal surface against reaching 1000 F. for 30 minutes while being subjected to 2000 F. flame recently has been announced.

The Insul-Mastic fire-retardant is a heavy-bodied black mastic which can be sprayed or trowelled to a thickness of one-fourth to three-eighths inch on metal, wood, fibreboard and other materials. It

New Equipment is news!

It is for this reason that PETROLEUM REFINER devotes an entire section to the new products and literature presented by various manufacturers to the men of the refining-petrochemical-natural gasoline industry.

The equipment items presented in this section have been carefully screened by our New Equipment Editor so that you may keep pace with the new products in this constantly changing industry.

Engineers from Blaw-Knox and Arthur D. Little, Inc., make intermediate check on data as operator (on left) watches signals on control console of electronic computor

Power Piping Division develops

new "6 x 6" Flexibility Matrix Method —cuts calculation time from months to a day

Present day operating requirements demand power piping systems that can handle extremely high temperatures and pressures—often up to 4500 psi and 1100° F. Under these critical conditions pipe may expand as much as ten inches in a hundred feet of pipe.

To be sure of adequate flexibility of the piping system, the terrific stresses set up by this expansion must be accurately computed before fabrication. And these computations are often so complex that skilled stress analysts have had to take two to three months, sometimes more, to complete them.

Now, by using the Blaw-Knox "6 x 6" Flexibility Matrix Method, computation time is cut to one day.

Developed in an 18-month joint research project of the Blaw-Knox Power Piping Division and the Arthur D. Little, Incorporated, Cambridge, Mass., research consultants, this new method of computation takes advantage of the high speed and accuracy of electronic computers.

Results are: Completely automatic computation with no limitations on the complexity of the systems. Full accuracy—as any inconsistencies in the input data are detected by the machine and all results are carried to six significant figures. Tremendous saving in time. Highly profitable saving in costs.

Originally developed for calculating stress analysis on systems fabricated or designed by Blaw-Knox Power Piping Division, this new method of computation is now available to consulting engineers, companies and individuals responsible for the design of power piping systems.

Bring your piping stress problems to our Power Piping Division for a discussion with our experienced piping engineers.

BLAW-KNOX

BLAW-KNOX COMPANY
Power Piping and Sprinkler Division
Pittsburgh 33, Pennsylvania

Complete facilities for prefabrication and erection of piping systems—complete line of functional spring hangers, assemblies and vibration eliminators—complete engineering and installation of Automatic Sprinkler Systems

For more data on advertised products, use Readers' Service Cards, last page.

safe
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HIGH-PRESSURE
NEEDLE VALVES

Forged steel valves in ¼" – ⅜" – ½" or ¾" sizes for high-pressure throttling gauging or sampling services. The safety bonnet type meets exacting safety requirements.

Available in 416 Stainless Steel – other alloys to special order.

ENGINEERS . . . write for illustrated Bulletin 101.

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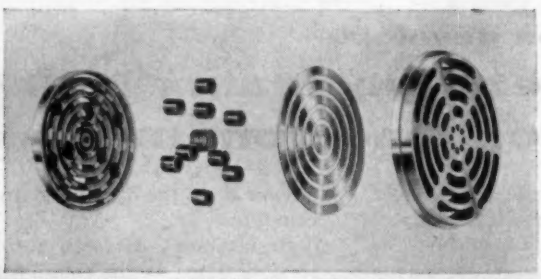
VOSS VALVES in your machine mean



LESS MAINTENANCE, FEWER SHUTDOWNS for your compressor. (air, gas, ammonia)

- up to 40% more valve area • minimum pressure loss • higher efficiency
- less power consumption • normal discharge temperature
- quiet, vibration-free • utmost safety • lower operating costs

VOSS VALVES are made to specification, machined from solid stock (not cast) – VALVES and PLATES are of heat-treated alloy or stainless steel; PLATES are machined, not stamped, and ground for precise close-tolerance fit; are dimensionally stable . . . ductile . . . resist fracture, high temperatures and corrosion . . . withstand fatigue. SPRINGS, of heavy rectangular sections and large diameters, add to dependability and safety.

Our detailed proposal will be sent without obligation. Send name, bore, stroke and speed of machine.

J.H.H. VOSS VALVES REG. U.S. PAT. OFF.
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New Equipment . . .

will not run, drip, drop off or contribute fuel to the flame. It was developed primarily as a fire and heat-retardant coating for metal vessels and equipment and for structural supports such as beams, posts, stanchions, etc.

In addition to its outstanding fire-retardant properties, the mastic serves as an interior or exterior coating to insulate, reduce condensation, rustproof and waterproof in the range of —20 F. to 250 F. It weathers well, withstands acid and alkali fumes and splash, and will not support mildew.

Coverage is economical with 20 gallons required per 100 square foot one-fourth inch thick. Conventional mastic spray equipment can be used. Insul-Mastic Corp.

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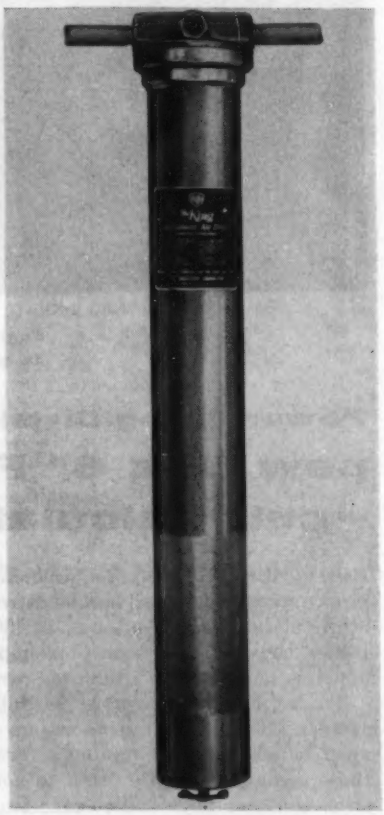


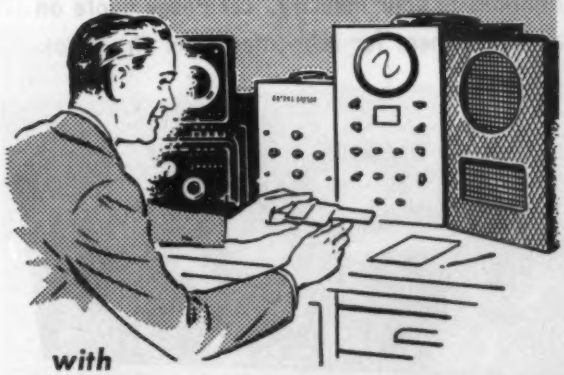
Instrument Air Dryer

A desiccant-type dehydrator for use in instrument lines has been announced. This unit is designed for removing water vapor from compressed gases serving liquid level gages, louver and damper operators, air valves and other pneumatic equipment on dead end or low flow service in remote locations. It provides a dew point of —60 F. or lower, can be used at a gage pressure of 100 psi, and has a capacity of 60 scfh at 70 F.

The air dryer consists of a head, a case, and an inexpensive desiccant cartridge. The head is mounted "straight through" in the line, and does not have to be removed for servicing. The case, containing the cartridge, screws onto the head, and has a drain cock in the bottom.

The air enters from the right, then

STOP
EXHAUST NOISE and PIPING VIBRATION



with
BURGESS-MANNING SNUBBERS

Burgess-Manning engineers have spent years of scientific research into the cause and nature of exhaust noise and pipe line vibration. Out of this research came the Burgess-Manning Snubbing Principle.

Throughout the world, Burgess-Manning Snubbers, utilizing this unique principle, are eliminating the deafening, efficiency-reducing roar of engine exhaust and the destructive effects of pipe system vibration and pulsation where compressible gases are pumped.

Engineered by specialists for the specific applications, Burgess-Manning Snubbers pay for themselves in increased efficiency of equipment and personnel, lowered maintenance costs, improved labor and neighborhood relations.

This engineering service, with years of experience in the elimination of noise and vibration, is available for consultation on your problem without obligation.

Write for copies of case histories of typical installations.

Present your problems for Analysis and Recommendations

BURGESS-MANNING COMPANY
Sound Engineering
711 East Park Avenue, Libertyville, Illinois
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As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL
The Simplest, Most Versatile LIQUID LEVEL CONTROL Ever Devised!

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life*, with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

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Please send me catalog data and full information on Magnetrol Liquid Level Controls.
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Company_____
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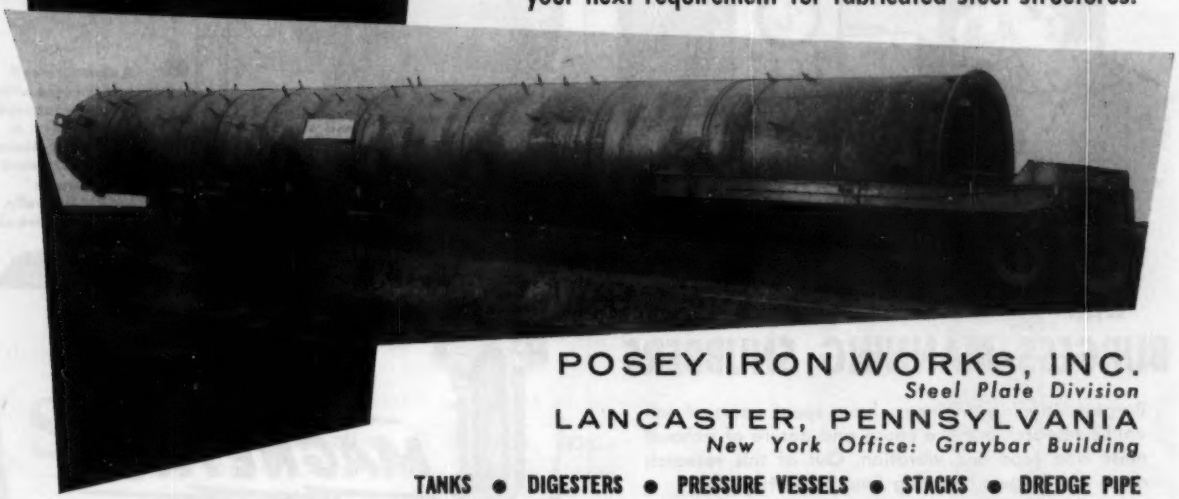
For more data on advertised products, use Readers' Service Cards, last page.

POSEY TOWERS

Feed Splitters like this one . . . 98′ long by 10′ I.D., and now in service in one of the East Coast's largest plants . . . must be precision-built from beginning to end.

Posey Iron has the experience, the facilities and equipment, as well as the skilled men to turn out a flawless job every time. Write for information about Posey installations in your industry. Let Posey quote on your next requirement for fabricated steel structures.



POSEY IRON WORKS, INC.
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New York Office: Graybar Building

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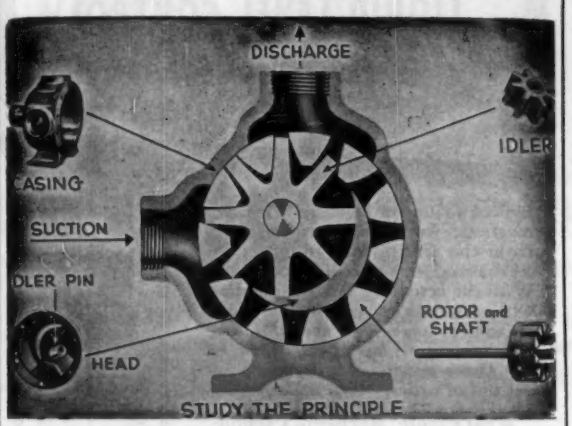
Viking Operating Principle



Above are illustrated the major parts of the Viking Pump—casing, head, rotor and idler, separately and assembled. Imagine the rotor and idler in motion operating in a counterclockwise direction. Follow the course of the liquid from point of suction to point of discharge. Reverse direction will operate equally well. We invite your inquiries.

Distributors

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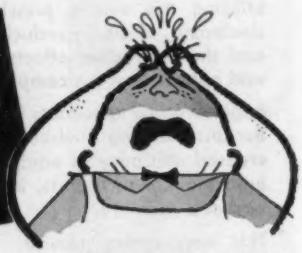
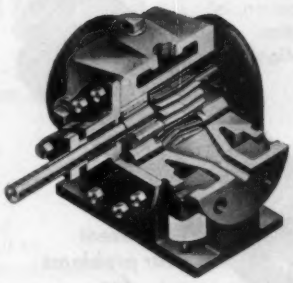
MANUFACTURERS • MACHINERY FACTORS • CONTRACTORS
Service Facilities at: Houston–Dallas–Kilgore–San Antonio–Edinburg Corpus Christi and Beaumont, Texas

DON'T GIVE UP when viscous liquids cause pumping problems . . .





An SK Steam Jacketed Gear Pump can restore that old equanimity—keep the brass happy and you smiling.

Engineers and production men in many varied industries are using SK Steam Jacketed Herringbone Gear Pumps to handle viscous materials of many types—heavy fuel oils, asphalt, vegetable shortening, glue, and others.

Take a tip from these folks. Send for a copy of Bulletin 17-A which describes SK's line of pumps. Or, acquaint us with your problem. We'll help.

Schutte and Koerting COMPANY
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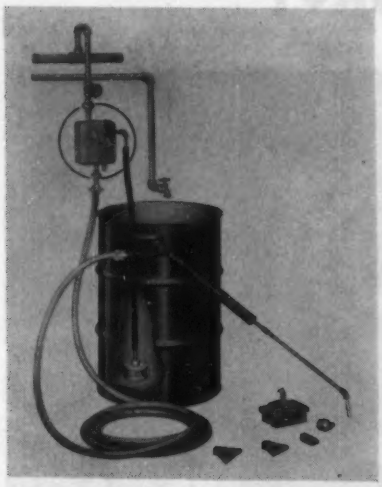
2257 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

Jet Apparatus: Ask for Condensed Bulletin J-1.	Rotameters & Flow Indicators: Ask for Condensed Bulletin 18-RA.	Valves: Ask for Condensed Bulletin V-1.	Heat Transfer Apparatus: Ask for Condensed Bulletin HT-1.	Gear Pumps: Ask for Bulletin 17-A.

New Equipment . . .

flows down around and up through the cartridge, and through a saturation indicator in the head. The indicator turns from blue to pink when the cartridge needs changing. A change of cartridge is quickly made without tools; and the saturated cartridge can be reactivated by heating in an oven. King Engineering Corp. **Circle E4, green card, last page**



Hydro Steam Cleaner

A new steam cleaning unit weighing only 15 pounds—44 percent lighter and 20 percent lower priced than previous models has just been announced.

This new model S-809 is the first to offer single valve control of hot cleaning solution plus a visual gage constantly showing steam pressures. Extremely simple, with no motor, pump or electrical connections, the control cabinet can be readily connected to any ¾-inch valve steam outlet. That steam line, with pressure of 40 pounds or more, supplies the only power required. Cleaning operations can begin immediately, without waiting for a warmup.

As shown in the cut-away illustration, cleaning solution is picked up in a metered amount by a strainer-protected suction head immersed in a drum or other recepticle, mixed and heated with live steam, and delivered in a driving spray through the gun nozzle. The single lever on the cabinet varies capacity from 120 to 190 GPH of hot cleaning solution. This same valve also controls temperatures of the solution and velocity of discharge at the gun nozzle.

Upon completing one cleaning job, the control cabinet can be quickly disconnected from the steam outlet and easily carried to any other location in plant or yard, wherever steam is available. For easy portability, the drum of cleaning solution can be mounted on a swivel-caster pallet. Clayton Manufacturing Company.

Circle E5, green card, last page

Former Research Chemical Is Now Potential Catalyst

Titanium trichloride, a chemical which has been previously obtainable only in small (ounce or gram) quantities for re-

HILLS-McCANNAMETER

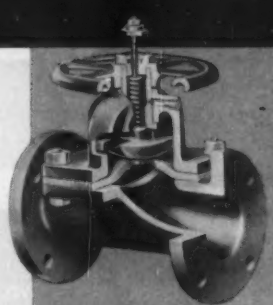
meters and pumps with unfailing accuracy

A packless, positive displacement pump, the Hills-McCannameter operates on an entirely new pumping principle to create a new high in metering accuracy, a new low in operating costs. Maintenance simplified through unique capsulated construction. Perfect for laboratory and production proportioning of low viscosity fluids over extended time periods. Send for informative booklet "The Meter That Pumps."

PAT. APPLIED FOR

hills-mccanna company

THE PEOPLE WHO KNOW AND CONTROL FLOW



DIAPHRAGM VALVES with the exclusive Hills-McCanna Sealing Bead Diaphragm

Hills-McCanna Diaphragm Valves are available in a variety of materials to offer positive control for all gas, liquid and corrosive services. Features simplified, maintenance-free construction. Write for 12 page Valve booklet.

Hills-McCanna Company 2441 W. Nelson Ave., Chicago 18, Illinois

exhaustive tests prove:

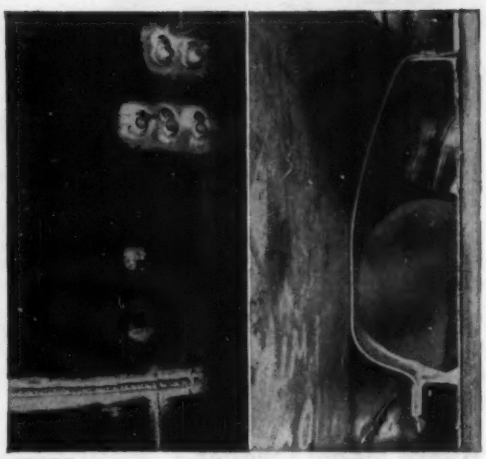
36 YEARS FROM TODAY

TUBESEALS* NOW IN FLOATING ROOF TANKS WILL OPERATE AS EFFICIENTLY AS THEY DO TODAY!

WE DOUBT this can be claimed for any other floating roof seal!

To determine the efficient life-expectancy of the Hammond Tubeseal in service, tests were made under the worst possible conditions to which a floating roof seal can be subjected. The Tubeseal was moved across very rough rivet heads, erection burrs and abrasive weld surfaces, for a total travel of 70,000 feet. This is equivalent to a normal wear of *more than 36 years in actual service.* Moreover, as the tests were run dry, there was the added disadvantage of the absence of lubricating effect normally created by wetted surfaces. Upon completion of these rigorous tests, the scuff band had only worn through the ribs and had barely penetrated through the material, leaving two-thirds of the stock intact; proof that the Tubeseal is unimpaired after traveling 70,000 feet.

The 36 year life-expectancy of a Hammond Tubeseal assumes no mechanical accident and is arrived at in the following manner: Each year a floating roof, in normal service, makes about 48 trips to and from top and bottom of tank. The roof of a 40 foot tank, therefore, will travel 1920 feet per year. Assuming 1920 feet of travel per year (based upon full depth of travel) and applying our accelerated wear test, the Tubeseal will be serviceable for at least 36 years 5½ months.



THE TUBESEAL TEST:

total travel	70,000 feet
travel over vertical weld	46,400 feet (on same line)
Horizontal welded seam crossed	21,200 times
Flat head rivets crossed	63,600 times

CONDITION OF TUBESEAL AFTER TEST: Scuff band had worn through ribs and had barely penetrated into the main material, leaving ⅓ of stock intact.

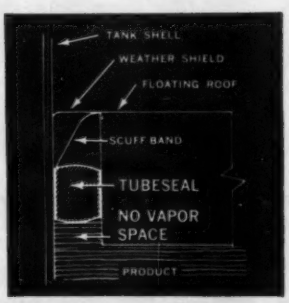
Tests were conducted dry with no aid of lubricant normally resulting from stored product.

Photos show projections used for test. Included are 16" of ⅜" horizontal weld—24" of sharp, irregular vertical weld—2 erection burrs—3 ¾" flat head rivets and 2 ¾" cone head rivets.

THE HAMMOND TUBESEAL
is the most efficient and positive seal known.

it features:

no moving parts
no mechanical maintenance
climate proof
non-corrodible
can operate to bottom of tank or above the top
no vapor space below the seal
entire circumference has tight seal under pressure at all times
longer working life expectancy



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For more data on advertised products, use Readers' Service Cards, last page.

search purposes is now being manufactured on a semi-commercial basis in quantities ranging up to hundreds of pounds.

The trichloride is a fine, dark purple, crystalline powder, of high purity. In recent months it has attracted a great deal of research attention because of its potential application as a catalyst for the manufacture of isotactic polymers such as polypropylene, polybutene and polystyrene. It has been cited in the literature as being a promising catalyst for the production of Ziegler low pressure polyethylene, of a new cis-polybutadiene rubber, and for use in Friedel-Crafts type reactions.

A preliminary technical bulletin is now available. Staffer Chemical Company.

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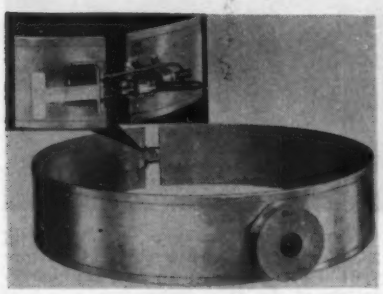

Quick Coupling Drum Heater

A new drum heater for facilitating content removal from 55 gallon steel drums has just been developed.

Known as the RH-1 Acrawatt, the heater features a new toggle clamp (shown in inset) for fast application and removal, and a built-in three-heat switch (lower right). Wiring circuits are said to assure uniform heating at either high, medium or low settings. Acra Electric Corp.

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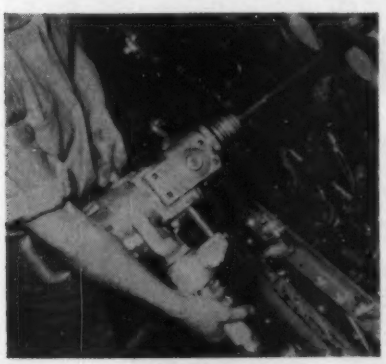

New Boiler Tube-Expander Provides Precise Control

A dial incorporated into the new air-powered tube-expander drive and control provides the control necessary for precise boiler-tube rolling. The operator has but to set the desired torque (in foot-pounds) on the dial and start the rolling operation; when the desired torque is obtained, the expander automatically stops rotating. Joint tightness is always uniform, regardless of tube-sheet hole variation. Guess

Now . . . get product uniformity . . . faster ...at less cost...with NETTCO Engineered Agitation!

AGITATION APPLICATION SPECIALISTS

MODEL WT AGITATORS typify the quality products offered by NETTCO . . . engineered to increase productivity, lower power costs, and minimize maintenance requirements. Meet your exact process specifications with standardized components . . . for lower initial investment . . . and be assured (because of design simplicity) of years of dependable, uninterrupted service. See what over fifty years of "engineered agitation" experience . . . in producing the most complete agitator line available . . . means to you!

Check the design features of the Model WT tank top agitator . . .

- Worm gear reduction drives
- Ratios from 3.5:1 to 68:1
- Twenty-seven sizes available
- Complete range of speeds
- Minimum moving parts
- Large diameter vertical shaft
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- Fully enclosed—dust, fume, moisture-proof
- Splash lubrication, drip-proof design
- Oil-trapped against leakage

Model T units, featuring helical gear trains and worm gears in combination, offer ratios from 6.25:1 to 100:1 plus many modifications to suit application needs. Send your process specifications to NETTCO agitation engineers for recommendations. Request Bulletin 551 and data sheet from New England Tank & Tower Co., 81 Tileston Street, Everett 49, Mass.

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FREE LITERATURE

Please send me the following literature:

- ☐ Tank Top Agitators—Bulletin 551
- ☐ Portable & Tripod Mixers—Spec. Sheets
- ☐ Pipeline-Flomix®—Bulletin 531
- ☐ Side Entering—Bulletin 532

New Equipment...

work is taken out of tube expanding because the operator does not have to depend on expander resistance, motor sound, or "feel" to determine correct expansion. This feature makes the tool easy to use, even by untrained personnel, and eliminates over- and under-rolling.

The Model C is designed for a wide range of boiler tubes, from one to two and one-half inches O.D. The new model produces 75 foot-pounds of torque, powerful enough to roll three-inch No. 10-gage tubes in a five-eighths-inch-thick sheet. Itis a completely integrated one-piece device. With an air hose as the only external connection, the unit is not cumbersome, and there are no delicate auxiliary parts that might be broken. Thomas C. Wilson, Inc.

Circle E8, green card, last page

Reprint Details Automation For Feedwater Treating

A new technical article on automation of water treatment plants is now available.

Automation, one of the foremost topics in the engineering field today, is finding wide applicaton in the boiler feedwater and process water treatment fields. With the percentage of automatic plants being installed growing enormously each year, this subject is of great interest to all persons coming in contact with the water treatment field.

Technical Reprint T-148 discusses this important development in detail. Several specific case histories are presented pointing out the problems involved and the methods of solution. Flow diagrams of these plants are shown to allow the reader to understand the problem and solution.

Of particular interest will be the fact that the authors have presented several important classification breakdowns. Water treatment processes and equipment are divided into three groups—mechanical, chemical and ion exchange. These are further divided to indicate the many subdivisions and types of process. The types of measurements required by the processes and the types of control systems are also classified and discussed.

The article also presents, in addition to many illustrations, a chart of the various types of demineralizers available, their application and advantages. Graver Water Conditioning Co.

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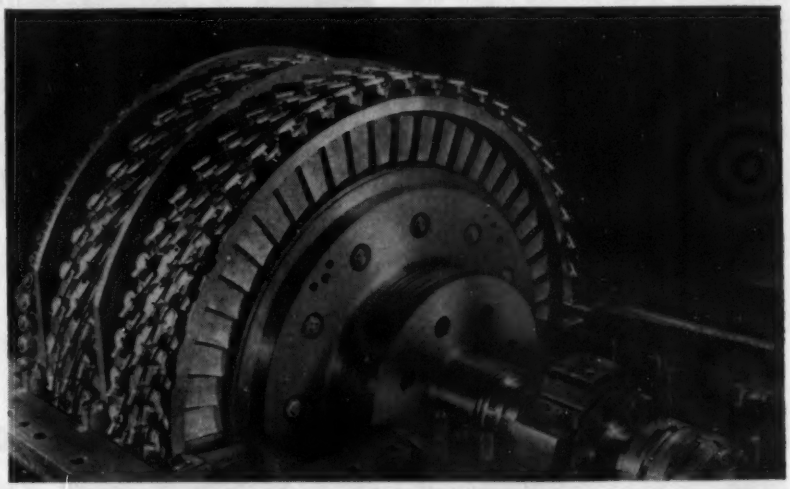

New Model Axial Compressor

Introduction of new type axial compressors with full stator blade control for extended range of operating conditions with high efficiency has just been announced.

The new model axial compressors can be used with almost the same capacity variation as centrifugal units and still maintain the high efficiency and pressure rises at part load points which are characteristic of the axial compressor.

The new machines are particularly adapted for large volume applications where capacity variation is necessary in oil refineries and chemical plants. This is particularly true where large electric

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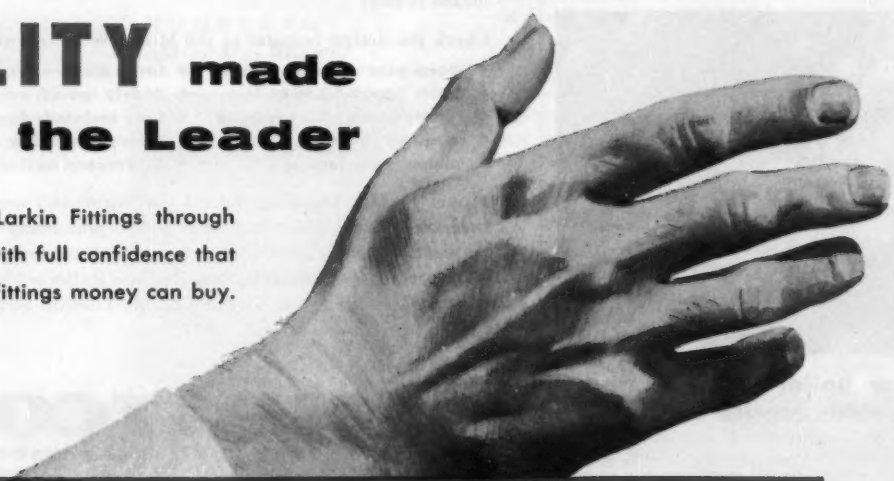

Hexagonal Swages and Bull Plugs • External Upset Swages and Sub-Tubing Nipples • Refinery Swaged Nipples and Bull Plugs • Seamless Casing Nipples • Seamless Tubing Nipples • Steel Tubing Couplings • Substitute Couplings • Sub-Tubing Nipples and Pup Joints • Perforated Tubing Nipples • Adaptor Nipples • Boiler Nipples • Choke Nipples.

New Equipment . . .

motor drives are used and constant speed operation is preferred in order to take advantage of the lower initial cost and more favorable operating characteristics of a synchronous motor.

Each row of stator blades has a hydraulic master positioner or electric motors through gearing which are used to position the blades. This type of arrangement allows individual rows of stator blades to be adjusted separately or all can be tied together to move at one time. Usually, the latter type of operation is all that is needed unless extremely fine control variation is necessary. Then the individual rows can be adjusted separately for optimum operation. Allis-Chalmers Manufacturing Co.

Circle E10, green card, last page

Teflon Liner Bulletin

Publication of a bulletin on "Teflon" lined steel pipe is now announced. "Teflon" is a DuPont tradename for tetrafluoroethylene resin.

Bulletin T-100 details the application of "Teflon" as a liner for schedule 80 steel pipe. This rugged assembly can solve the toughest corrosion problems in chemical, petroleum, pharmaceutical and food processing, plus other allied industries. "Teflon's" almost complete resistance to chemical attack assures a near limitless service life.

Pipe lined with "Teflon" will withstand temperatures as high as 350 F. Working pressures of this piping are limited by the flange strength. Standard flange strengths are available at 125#, 250# and 300#. Standard sizes are 1, 1½, 2, and 4 inches, standard lengths in 2, 5, and 10 foot sections. Haveg Industries, Inc.

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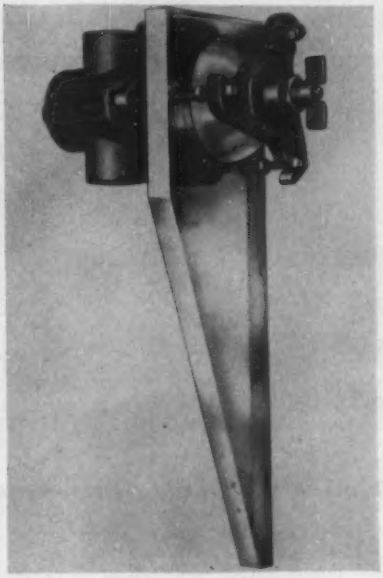

Plastic Wedge Lighting Illuminates Level Gages

A new illuminator gives up to three times the illumination and three times the bulb life. It lights up entire gage glass length with a bright, evenly diffused light. There are no glare spots or blinding areas so the liquid level can be seen clearly and easily under all conditions.

The illuminators are easily mounted on the back of transparent gages. They incorporate the principle of solid wedge lighting; illumination from a single bulb is reflected from the angular surface of the plastic wedge and is evenly diffused through the transparent gage glass, at a cost so low that savings quickly pay for the illuminator.

The plastic wedge is mounted so that there is space between it and the gage glass, facilitating cleaning and leaving an air-cooling space which allows the illuminator to be used on higher temperature gages. Jerguson Gage & Valve Company.

Circle E12, green card, last page

Solvent Motor Cleaner Won't Damage Insulation

Nonflammable solvents that will bite into and remove oil, grease, and dirt without harming delicate metal parts or electrical insulation, yet are safe enough to use in ordinary work areas with conventional ventilating equipment, are now available to solve a wide range of special industrial cleaning problems.

Adaptable to vapor degreasing or cleaning by liquid immersion, the solvents will be marketed under the "Freon" trademark.

Big advantage of the "Freon" solvents, rests in their safety, both from a personnel exposure and material standpoint. Because they are nonflammable and nonexplosive, they can be used in open shop areas without danger of fire.

Most important use proved to date is in cleaning of electrical motors, both new and reconditioned. Biggest problem there in the past has been the tendency of cleaning solvents to attack insulation on the motor wiring, weakening or removing it sufficiently to cause short-circuits when the motor is placed in operation. Three

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New Equipment . . .

years of test indicate that the "Freon" solvents will not soften, craze or dissolve any of the commonly used wiring insulation materials. E. I. du Pont de Nemours & Company, Inc.

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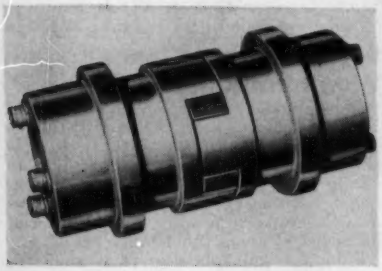
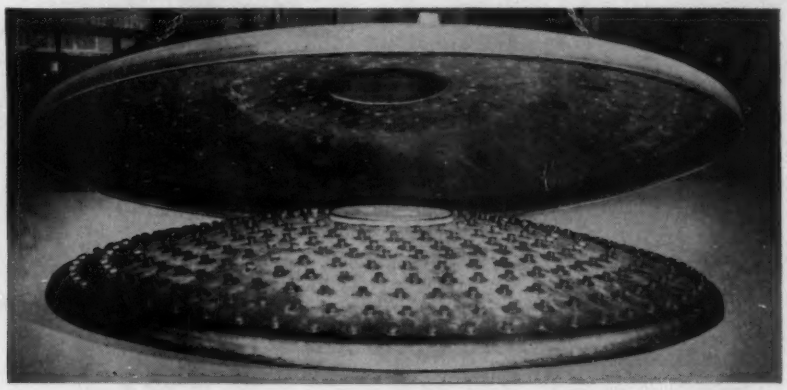


New Flexible Coupling Permits Easy Dissassembly

A radially removable flexible coupling which provides a simple means of disconnecting two units without axial movement of the shafts has been developed.

This coupling simplifies maintenance and is ideal for applications where driven equipment such as a pump must be disconneted while the driving unit continues to operate. All that is necessary in such cases is to disassemble the coupling itself.

Completely maintenance and lubrication-free, the coupling is extremely rugged and simple in design. There is no wear on the metal jaws since the load is transmitted by compression of the one-piece load cushion. Love Joy Flexible Coupling Co. **Circle E14, green card, last page**



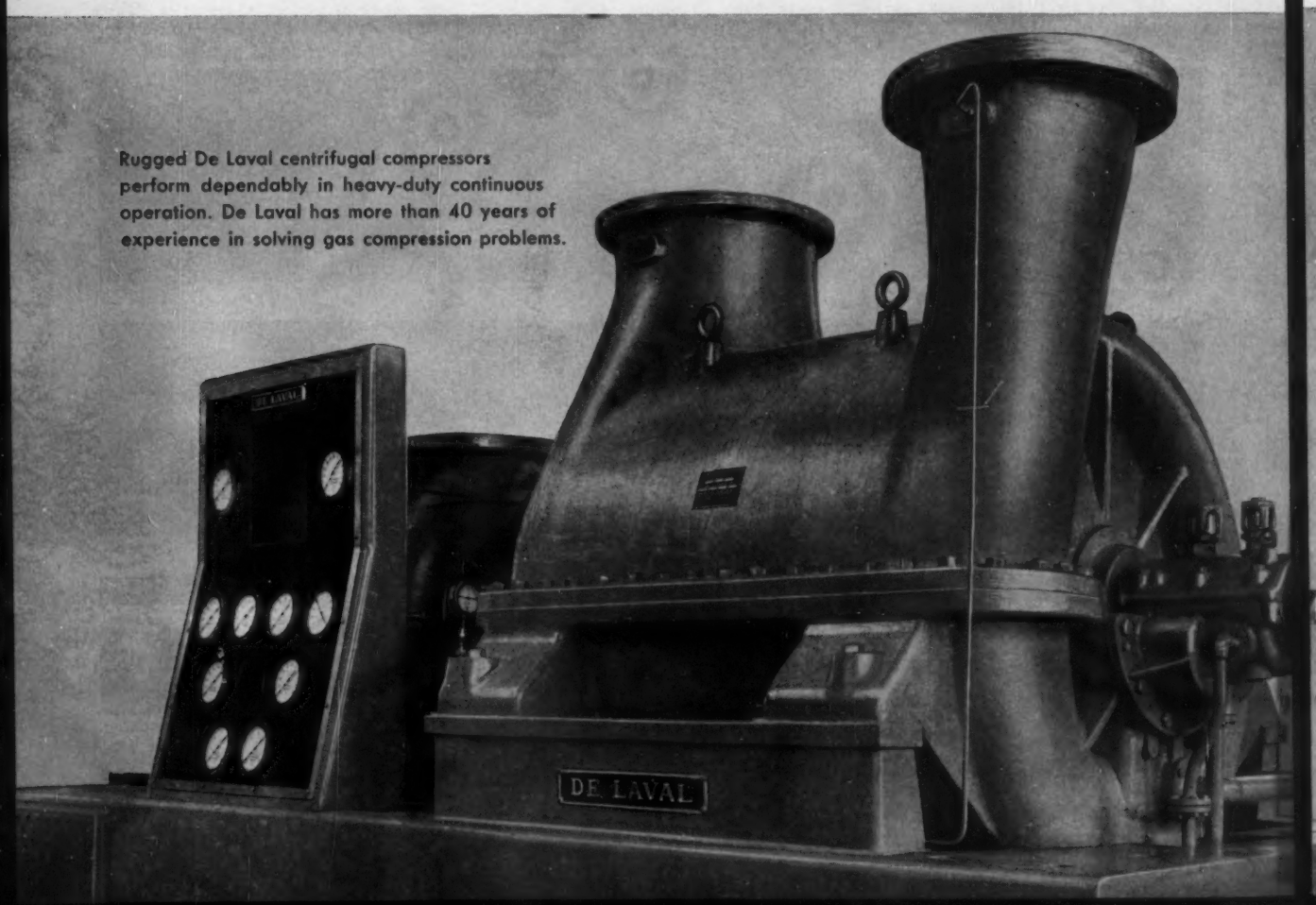
Plug Weld Quality Improved by Using CO_2

Development of a more efficient plug welding technique was brought about by the production of several steam jacketed stainless vessels involving thousands of stay bolts with 1-inch plug welds.

After conducting numerous experiments an efficient plug welding technique was developed by adapting an active gas shielding consumable electrode welding process.

The end result was a constant voltage motor generator power unit, simplified constant speed wire feeding device, proper welding grade CO_2, regulating equipment, and manual gun with built-in finger tip control.

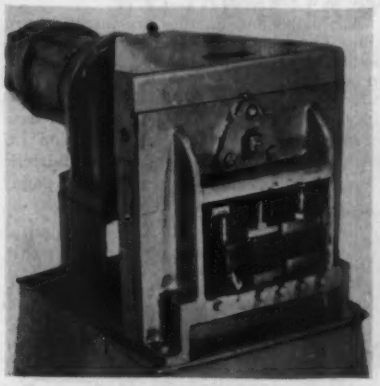
The optimum specification for this type of operation proved to be 35 cubic feet per hour of carbon dioxide and a speed of 500 inches per minute of an approved



Rugged De Laval centrifugal compressors perform dependably in heavy-duty continuous operation. De Laval has more than 40 years of experience in solving gas compression problems.

type CO_2 electrode iwth an arc voltage of approximately 42 volts at a level of 400 amperes. Chicago Steel Tank Co.

Circle E15, green card, last page



New Pipe Notcher Makes Fit-up Joints

A 24-page brochure describing the operation of a completely new pipe notching device, together with a sample of the burr-free results obtained with this machine, is now available.

The notcher can retain up to four sets of dies, always set up and ready to go. It is more economical than a press, is faster than a mill and is more flexible than either or both.

This precision machine is manufactured by skilled craftsmen in West Germany. Wallace Supplies Mfg. Co.

Circle E16, green card, last page

Stirring and Mixing Booklet

Stirrers, Mixers & Shakers is the title of a new 16-page booklet just published.

Stirring, mixing and shaking have always been basic laboratory operations; one of the oldest lab manuals in existence contains instructions for the chemist to "invert ye Container 1000 Times" before sampling.

Today, there are dozens of different devices for accomplishing these operations quickly, efficiently, automatically.

The bulletin describes Air-Driven, Electric, Glass and Magnetic Stirrers . . . Stirring Electrodes . . . "Fultork" Labmotors . . . Blendor-Type Apparatus . . . Oscillating Hot-plate Wrist-Action Shakers . . . ultrafast Vibro-Mixer . . . new Thermix (stirrer-and-hot-plate) . . . and Fisher-Kendall Mixer, first automatic mixer that completely incorporates the intricate action of the human hand in dry and liquid blending. Fisher Scientific Company.

Circle E17, green card, last page

New Line of Tank Fittings

A new line of tank fittings including breather vents, hatches, drain valves and Automatic Tank Gauges is completely described and illustrated in Catalog Number 66. Wheaton Brass Works.

Circle E18, green card, last page

New Equipment . . .

Non-Skid Gratings, Treads

A new design of non-skid gratings and treads in which a non-absorbent hard and tough abrasive is baked into V-shaped openings made along the top surfaces, has been developed.

The abrasive presents a non-skid surface that is not subject to attack by chemicals. It remains effective in the presence of oil and water as well as when the surface is dry. The abrasive stands a little above the surfaces of the bars and is embedded about one-eighth inch in depth.

A six-page illustrated catalog R-655 is available to safety engineers and other industry personnel. This catalog includes a safe load table showing the available sizes of grating sections and their load capaci-

DE LAVAL
CENTRIFUGAL
COMPRESSOR

helps boost cat-cracker capacity at Shell Oil of Canada, Limited

To obtain extra capacity, the Montreal East refinery of the Shell Oil Company of Canada, Limited decided to rebuild its cat-cracker. Since the modernized cracking unit required a greater volume of air, Shell of Canada selected a dependable De Laval centrifugal compressor handling 16,400 cfm.

This compressor operates at an inlet pressure of 14.3 psia and a discharge pressure of 42.8 psia. The power required is 1860 bhp with the compressor operating at 5400 rpm.

The Shell Oil Company of Canada, Limited is another refinery which has chosen De Laval compressors for heavy-duty continuous service. Whether you need to handle light or heavy gases at high or low pressures in catalytic cracking, reforming, alkylation, coking or any similar service, it pays to look to De Laval.

Send for Bulletin 0504

DE LAVAL *Centrifugal Compressors*

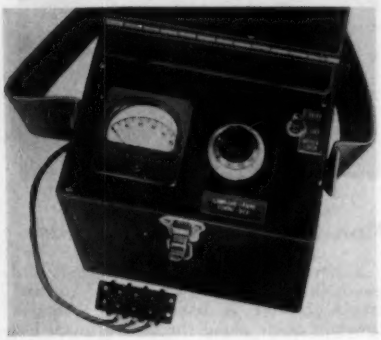
DE LAVAL STEAM TURBINE COMPANY

811 Nottingham Way, Trenton 2, New Jersey

DL379

New Equipment . . .

ties as well as tread sections, dimensions and load ratings. Reliance Steel Products Co. **Circle E19, green card, last page**



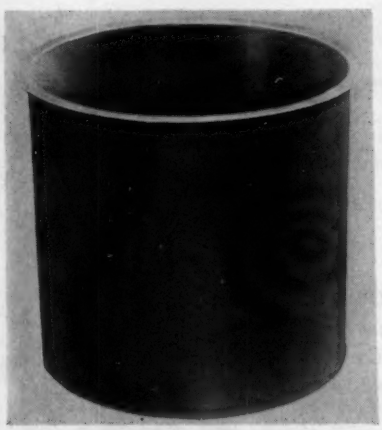
Portable Corrosion Meter

With battery operation, this new corrosion meter can be used successfully in the field or in the lab. It weighs only nine pounds and comes in an aluminum carrying case.

Circuit is full transistor type and is shock proof. Single knob control measures corrosion as low as 0.000001 inches.

"Corro-Dex" is suitable for corrosion tests in chemical plants; determining inhibitor characteristics for oils and gasolines; effectiveness of cathodic potential protection devices, etc. Labline, Inc.

Circle E20, green card, last page



Corrosion Resistant Tanks

Light and heavy-duty polyester glass tanks, like the one here shown, offer excellent resistance to the effects of brine and other corrosive solutions. Tanks can be had in almost unlimited sizes—even up to 30,000 gallons. These polyester glass tanks are also extremely light, making for ease of installation. Prices are substantially less than for tanks of similar sizes in corrosion resistant metals. Also in this brine application, resistance is claimed to be far superior to that of mild steel. Haveg Industries, Inc.

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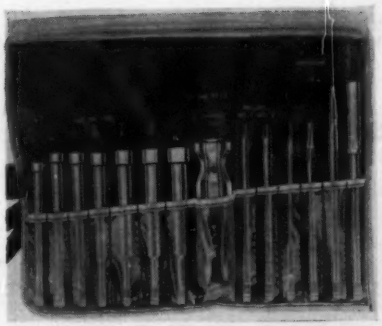
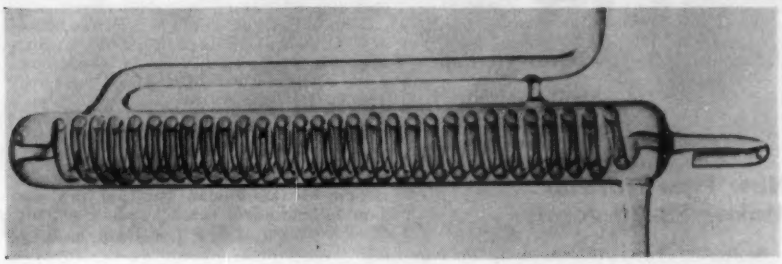


Lab Tool Kit

A new tool kit for laboratory technicians is now available. The kits have been designed to meet the demand for an all-purpose set of tools in one handy carrying case at a low cost.

All blades and handles are interchangeable. The smaller of the two kits includes an Amberyl handle and six screw drivers in a seven section plastic tool roll. The larger, all-purpose kit includes a heavy-duty handle, five screw drivers, seven hex wrenches and one five inch extension in a fourteen section plastic tool roll. Burrell Corp. **Circle E22, green card, last page**



Efficient Condensation Trap

A new type of condensation trap to more efficiently trap volatile compounds has just been designed and manufactured.

The all-glass trap is designed for use where quantitative condensation is required in the vacuum manipulation of hydrocarbons and other volatile compounds.

The product can also be used as a vacuum system for trap and as a collector in air pollution analyses.

When the trap is immersed, coolant fills the inner glass spiral and surrounds the outer surface of the trap. The inner spiral provides a minimum of 50 percent greater cold surface for condensation with the same external dimensions of conventional traps.

Slush baths can be used as coolants if desired. The upper extension of the spiral is bent downward as a return for liquid nitrogen coolant which pumps back into the Dewar flask when the trap is first immersed. Scientific Glass Co.

Circle E23, green card, last page

Injection Assembly Speeds Analysis

A new sample injection assembly and two unique sample pipets have increased the precision of simultaneous qualitative and quantitative analysis by gas chromatography.

The new assembly replaces the Partitioner's regular sample-injection unit. Using one of the new pipets, an experienced operator can reproduce the volume of a 0.001-ml liquid sample within ± 0.3 percent, time after time. And in a field test, a series of operators who had never used the Partitioner before repeated the sample size within ± 0.8 percent. Fisher Scientific Company.

Circle E24, green card, last page

Now...from Tracerlab...

A 50-CHANNEL SCANNING SPECTROMETER SYSTEM

with automatic digital readout

TRACERLAB RLP-6
50-CHANNEL SCANNING SPECTROMETER SYSTEM,
here shown with optional Ratemeter.

Complete system for assaying radioactive samples quantitatively on continuous or stepwise basis consists of:

- **Precision high voltage power supply**
- **Pulse height analyzer**
- **Linear amplifier**
- **Preset count and preset time scaler**
- **Automatic digital readout**
- **Building block design principle for easy tie-in with other Tracerlab equipment.**

The accuracy of digital readout, heretofore available only in multi-channel analyzers, may be obtained from the Tracerlab RLP-6 50-Channel Scanning Spectrometer System at a cost comparable to the conventional single channel spectrometer system with ratemeter-recorder. It can be used with an automatic sample changer.

For complete information, write for Tracerlog No. 78.

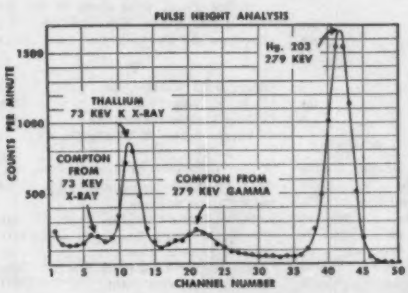
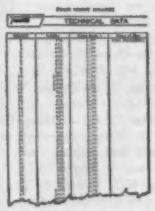


CHART OF SPECTRUM OBTAINED FROM Hg 203 shows plot of data from sheet pictured below.



DATA FROM AUTOMATIC READOUT TYPEWRITER includes channel number, count, time in minutes, time of day.

Tracerlab

1601 Trapelo Road • Waltham 54, Mass.
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Offices in principal cities throughout the world.

...No Equal for Quick Pipe Threading

...these handy efficient

RIDGID

Drop-Head Dies

A die head for each size, ⅛" to 2"—they snap into ratchet ring from either side, can't fall out—reverse for close threads. Tough malleable and steel heads, famous RIDGID long-wear dies—conduit or special dies available. OOR and OR, ⅛" to 1"; 111R and 11R, ⅛" to 1¼"; 12R, ¼" to 2". Bargains in fast easy threading—at your Supply House.

The Ridge Tool Company • Elyria, Ohio, U. S. A.

RIDGID
Work-Saver Pipe Tools

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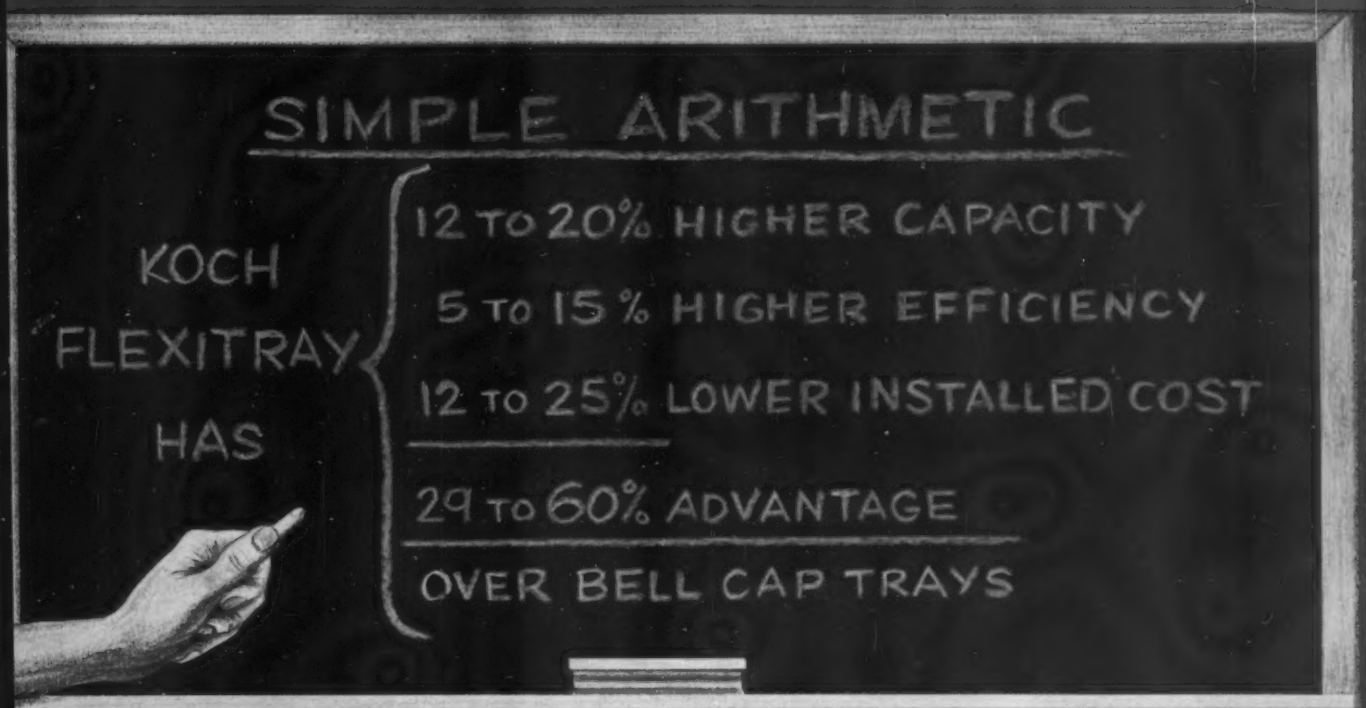
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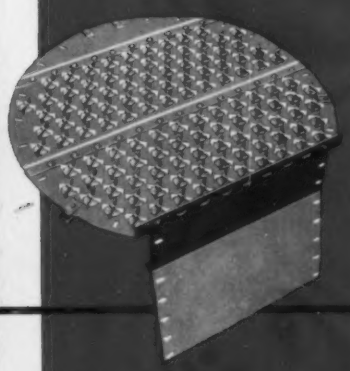

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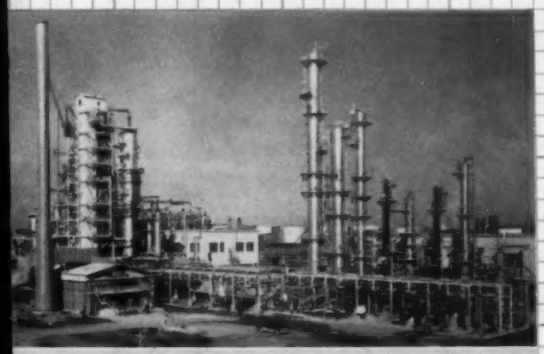

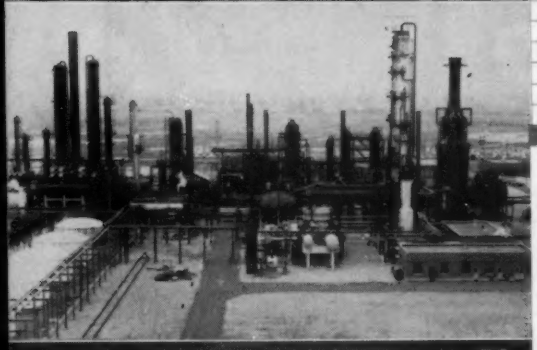

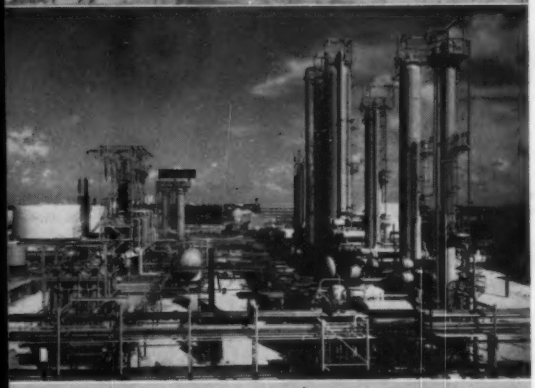

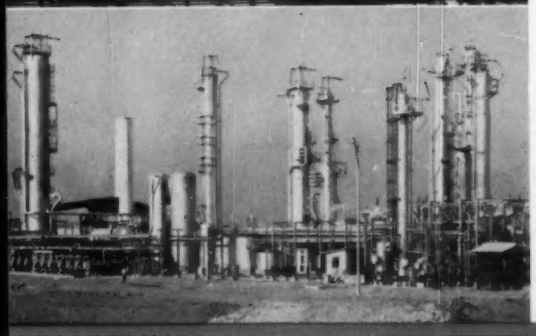

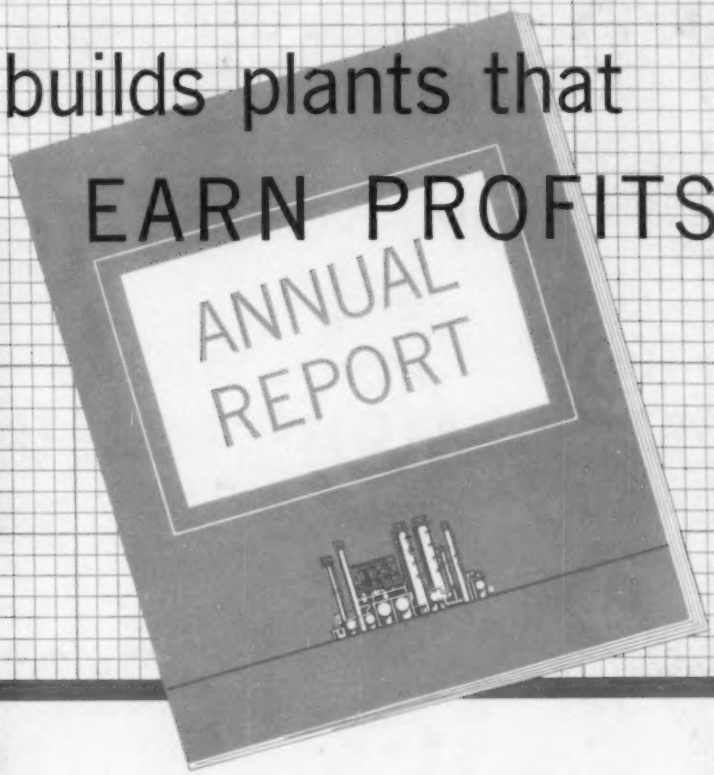

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